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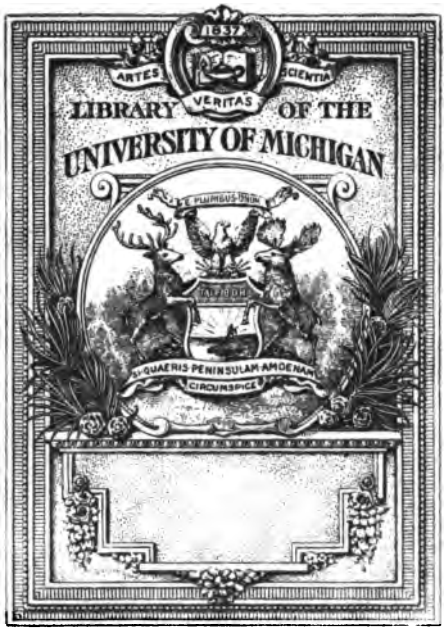
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WESTERN AUSTRALIA.

DEPARTMENT OF MINES.

REPORT

ON THE

MINES OF THE YILGARN GOLDFIELD.

BY

A. MONTGOMERY, M.A., F.G.S.,

State Mining Engineer.

Issued under the authority of the Hon. Minister for Mines.

PERTH, 14th SEPTEMBER, 1908.

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REPORT

ON THE

MINES OF THE YILGARN GOLDFIELD.

Office of the State Mining Engineer,
Mines Department, Perth, W.A.,
14th September, 1908.

The Secretary for Mines,
Perth, W.A.

Sir,

I have the honour to submit hereunder, for the information of the Hon. the Minister for Mines, a report on the mines of the Yilgarn Goldfield, which were examined by me during a visit extending from 4th to 16th of June last. Such an examination was necessarily of a very general nature, time not permitting surveys of mine workings or sampling of ore-bodies, and the report is to be taken accordingly as the result of somewhat general impressions received on a rapid tour round the various mines, and not as founded upon minute and thorough investigation of each.

The district has been already officially reported upon more than once, the latest comprehensive report being that of Mr. C. G. Gibson, B.E., Assistant Government Geologist, in Bulletin No. 17 of the Geological Survey of W.A., issued in 1904. This contains a geological map of the Southern Cross district and numerous illustrations, and should be constantly consulted while reading the present report. Mr. Gibson quotes previous official reports on the field by Mr. H. P. Woodward, F.G.S., when Government Geologist, and these need not therefore now be again mentioned in detail. Mr. Woodward's recent report (1907) on Fraser's Gold Mine, published in Bulletin No. 32 of the Geological Survey, is, however, of later date than Mr. Gibson's report and should be read with this one also.

GEOLOGICAL STRUCTURE OF THE FIELD.

The geological map of the Southern Cross district attached to Mr. Gibson's report serves very well to exemplify the structure of the mining centres of the goldfield generally, all being very similar.

Mining interest is practically confined to belts of dioritic country extending north-westerly across the field, the principal one of which is that seen at Golden Valley, Hope's Hill, and Southern Cross, and extending south-eastwards, with perhaps some interruptions by granite, to Jacoletti, Parker's Range, and Cheriton's Find. The Koolyanobbing Range and Mt. Jackson fields appear to be on parallel belts of dioritic country, separated from the Southern Cross belt by a wide area of granite. The granite country surrounding the dioritic belts has not as yet been proved to contain minerals of value.

The granite is pretty certainly, as elsewhere in our goldfields, of later date of formation than the dioritic country, and intrudes into the latter every here and there. Mr. Gibson has noted that the schistose portions of the diorite are found mostly along its contact with the granite, and that the lamination is parallel with the contact. He ascribes the schistose structure as most likely due to pressure due to the intrusion of the granite, which is very probable. As is mentioned hereunder when describing the Koolyanobbing Range, the granite is also at times changed to schist along the contact, but this does not appear to be very usual.

So far as my observations have yet gone I have seen no representatives in this field of the felsite and quartz porphyry dykes seen in the Norseman, Kalgoorlie, and Kanowna fields, except some rather doubtful quartz-porphyries at Koolyanobbing and possibly the white kaolin country near Jacoletti seen in the Exhibition and Alpha mines. The relations of these acidic igneous rocks to the main occurrences of granite are by no means clear even in the other fields mentioned where they can be better studied. They seem to me at present to belong most probably to an entirely different period of igneous activity.

Another series of acidic dykes is, however, very common in the Yilgarn fields, as will be seen from the frequent occurrence of them in the description hereunder of the various mines, namely those known to the miners of the field as "Mica-bars," otherwise pegmatitc dykes. These are very similar to dykes of like character found in the Phillips River field further south. They are generally of comparatively small thickness, often being only a few inches thick, and cut through not only the diorite country but also the lodes and reefs penetrating it. They do just the same in the Phillips River field, and both there and throughout Yilgarn are plainly much younger than the auriferous veins. So far as I have seen they rarely, if ever, fault the rocks through which they pass more than to the extent these are forced apart by the intrusion of the dyke. They do not appear to exercise any influence, favourable or the contrary, upon the values of the reefs traversed. They are however frequently a source of much trouble in mining, as the larger ones are expensive to penetrate, and where they pass through the reefs they cause large blanks in the substance of the latter, thus often greatly

reducing the amount of quartz which had been expected to be available in a given portion of the reef. It may be worth noting that the outcrop of one of these dykes, seen to the east of the McIntosh mine at Parker's Range, has been converted by weathering into a mixture of kaolin and brown iron ore, with micaceous scales of brown iron ore taking the place of the original mica, the whole much resembling the weathered outcrop of a lode.

Large areas of country throughout the Yilgarn fields are occupied by Salt Lakes, and round these there are usually extensive alluvial flats, in which the bedrock is quite hidden beneath superficial soil and other detritus. Much of the soil seems to be fertile land, and a good deal of farming on a small scale has lately been done round Southern Cross, good crops being obtainable when the seasons are favourable. A great deal of country has also been taken up for grazing purposes. Owing no doubt to the fertility of the country, it is heavily wooded with morrell and salmon gum forest, giving a splendid supply of mining timber and firewood. The Yilgarn Goldfield is certainly the most favourably situated in this respect in the State.

There are two other occurrences of geological interest in the district worthy of notice from a mining point of view as showing the former existence of conditions which must have had some influence on the ore-deposits. One is the section shown by the large excavated tank at Parker's Range, and the other the limestone deposits south-east of Southern Cross.

The Parker's Range Tank is a large excavation intended to impound storm water for a domestic supply to the district, but which has been a failure through the ground being so permeable that the water leaks out of it almost immediately. On examination it is seen that the rock in which it is excavated is not the ordinary dioritic country of the neighbourhood, but a roughly stratified sedimentary deposit of argillaceous sandstone and mudstones dipping westerly at an angle of about 20deg. from the horizontal. It is much broken by crevices and by numerous veins of impure quartz and siliceous iron ore. It rather closely resembles the rock described in my recent report on the Kanowna district at the building-stone quarries and the "Break-away," and I have little doubt is another similar remnant of a somewhat old sedimentary deposit which at one time covered a great deal of the interior of this State. As in the case of the Kanowna occurrences this one too is in low country close to the edge of a salt lake.

The limestone deposit is described at some length later on in this report and need not now be further referred to.

AURIFEROUS DEPOSITS.

Alluvial.—Comparatively little alluvial gold has been obtained in the Yilgarn Goldfield, and practically all of it has come from very shallow workings on or nearly upon the bedrock and the veins in

it from which the gold has been liberated by superficial denudation. Below Fraser's mine at Southern Cross, however, there is a small lead of ironstone "wash" running down to Lake Polaris, and which dips under the present bed of the lake, which indicates a certain amount of concentration of the surface material by ordinary alluvial action. There is a somewhat similar lead running east into the lake at Parker's Range. Neither of these has, however, been of much industrial importance. In my recent report on the Kanowna field, the formation of such leads was fully discussed, and nothing more need be said about the Yilgarn ones except pointing out that such leads dipping below the present lake bottoms may continue a long way under them, and are rather likely to carry both alluvial gold and impregnated deposits similar to the Kanowna "pug."

Lodes and Veins.—Nearly all the Yilgarn production of gold has come from veins of one sort and another, as will be seen by following the description of the various mines hereinafter mentioned. While examining the field it was impressed upon me that a good deal of the disfavour with which it has been regarded by prospectors, and even more by investors, has been due to the absence of an adequate conception of the nature of the ore-occurrences, which do not by any means fall in with the ordinary ideas of the behaviour of fissure-veins. They are often very irregular in shape, and break off and die out often for no apparent reason, and anyone accustomed only to the more normal type of fissure-vein is apt to regard them with great suspicion. The fact is that most of the quartz-veins which have been worked are only portions of much larger—and often very large—"lode formations," as they are commonly called for want of a comprehensive and well understood descriptive name. These are bands or zones of faulting in the country, often of great width, along which the rock has been disrupted and shattered, frequently with formation of fairly regular fissures along the general line of faulting, but also with a great deal of irregular crevicing. Lode-forming solutions traversing the fractured mass would naturally follow the most open crevices whether regular fissures or irregular cracks and the resulting ore-bodies therefore exhibit much variation in shape.

There appear to have been a number of different stages of formation of auriferous lodes in this district, and the best way of explaining them seems to be to discuss them from the point of view of their most probable origin, and succession in time. The oldest lodes are most likely those called on the Geological map the hematite-bearing quartzites. These are large lodes common in nearly all our goldfields from Phillips River to Pilbara, and consist of laminated finely-granular quartz—often very dark in colour—which may loosely be called quartzite from its very close resemblance to true quartzite, silicious to pure red and brown hematite and magnetite, and occasionally red and black jasper, with frequent ramifying veins of white quartz. In other parts they consist largely of laminated

kaolin and quartz veins. Usually the lamination is very regular, small pieces of the quartzite often resembling onyx, but sometimes the folia are very much contorted and crumpled. These lodes were pretty certainly "shear-zones" in the first instance, that is, lines along which the country rock became foliated through intense pressure and shearing stress, and probably usually yielded eventually so as to become faulted. In the Yilgarn district the quartzites run as a rule about parallel with the junction of the granite with the diorite country and parallel with the foliation of the diorite schists, and a similar parallelism with granite contacts is seen in some parts of the Murchison and Pibara Goldfields, but many of these lodes also are not at all near to such contacts. It seems rather probable, though of course we can have little absolute certainty on such a point, that they were formed about the time of the intrusion of the granite as the result of accompanying deep-seated movements of the earth's crust. The change of the laminated diorite to quartz and hematite would be due to deep-seated hydrothermal and pneumatolytic action, causing metasomatic replacement of the constituents of the diorite by silica and oxides of iron. In some of these bodies there is much pyrites in depth, which also would probably have a similar origin. These lodes often appear to carry from traces up to small weighable amounts of gold in them, though I have not myself met with any instances where they were authoritatively determined to contain anything like payable gold in their main mass. The first stage of their existence as lodes appears therefore to have been through the formation of the laminated hematitic quartzites, of much regularity of structure and containing no gold of industrial importance.

But in many instances there has been a second stage, in which they have been broken up by subsequent earth movements, and a second deposition of quartz, pyrites, etc., has occurred, frequently containing a good deal of gold and making them of importance as ore deposits. Several of the mines hereafter described in the Yilgarn field, the Craiggiemore mine near Laverton, the Westralia Mount Morgans mine at Mt. Morgans, the Lady Miller mine at Norseman, the Morning Star and St. George mines at Mt. Magnet, and numerous others, especially in the Murchison Goldfield, are cases in point where gold deposits occur in such laminated quartzite lodes which have been disrupted after their first formation. In some cases the mass of the old lode appears to have been greatly shattered right across and the crevices have become filled with splintery quartz, kaolin, and brown oxide of iron (doubtless pyrites in depth), all carrying gold; in others the breaks have been across the old lode, forming short ore-shoots at right angles to its course, and in others again the fracturing seems to have followed the foliation of the old lode, allowing veins of quartz of the fissure-vein type to be formed along its strike. The true fissure-vein lodes found parallel with the quartzites in several districts may very probably belong to the same

period of formation as these last, which have been formed within the older lodes. There are several examples of quartz reefs in the diorite country and of those within older lodes of quartzite more particularly described in the account given hereunder of the various mines at Yilgarn, and I am inclined to think that all these auriferous reefs most probably belong to about the same period of formation.

There is, however, yet another type of ore deposit in the district, in which the ore-bodies are found traversing a wide belt of shattered country not apparently directly connected with the hematitic quartzites. In these the diorite country has been disrupted, and doubtless faulted, and auriferous veins have been formed in portions of the shattered zones. These zones are very likely only another manifestation of the action of the same forces which shattered the quartzites and allowed formation of auriferous deposits in them, as it would be only to be expected that extensive earth movements would break the country in other places as well as along the old lodes. The more defined fissure lodes in the diorite country, those in the quartzites following their lamination, the ore bodies formed in shattered portions of the quartzite lodes, and those also in the shattered zones of the diorite country, may therefore very probably belong to the same period of formation, when rupturing and faulting movements of the rocks were followed by lode-forming activity along the crevices so formed.

The auriferous deposits have themselves, however, been often subsequently broken and faulted, so that other earth movements must have taken place after they were formed. These later movements probably account for the occurrence of barren quartz in close connection with auriferous stone, as in the case of Fraser's "buck" reef, and the barren stone in the Leviathan and other mines.

It is only by getting a clear conception of the probable mode of formation of the lodes that we can hope to understand the irregularities in the occurrence of the auriferous portions, especially in those which depart most from the normal fissure-vein type, and after examination of the district it seems to me that the appearances presented by the various ore bodies are only to be accounted for by some such explanation of their origin as the foregoing. Even the best defined fissure-veins, such as Fraser's reef at Southern Cross and the Jacoletti reef, exhibit in parts features relating them with the "shattered zone" type of deposit, and the former in places appears to be formed on the line of an older lode of laminated quartzite.

Some of the lodes of the Yilgarn district are now known to contain large quantities of sulphides below water level, as at the Transvaal and Greenmount mines, and it is pretty certain that others which show outcrops largely composed of brown oxide of iron will also prove to contain much pyrites in depth. In these lodes there is great probability that the chemical reactions taking place during the oxidation of the sulphides have affected the distribution of the gold in the superficial portions of the lode stuff. Some of the gold

which is found in fine leaves and scales through concretions of brown oxide of iron must have been deposited from solution at the same time as the brown iron ore, which is itself a well-known result of oxidation. The probable results of this chemical action as regards values of ore are discussed hereunder, when dealing with the Transvaal and Great Victoria mines.

The lodes of the Yilgarn field show a very strong resemblance to many of those in the Murchison, particularly to those in the Meekatharra district, where similar "shattered zone formations" are very much in evidence. They have not been well understood, and have not received the amount of exploration they undoubtedly deserve. The long mineral belt from Golden Valley to Cheriton's seems exceedingly well worth close attention from prospectors.

MINES VISITED.

Southern Cross Centre.

The position and geological relations of the Southern Cross reefs are well shown in Mr. Gibson's report. It will be noted that they are close to and generally more or less parallel with the line of contact between the greenstone and the granite country. The numerous laminated quartzite lodes are seen to be closely related to the auriferous reefs, many of the latter being actually in the former. The probable origin of these ore-bodies has already been alluded to.

At the time of my last visit to Southern Cross there was a great stagnation in mining work on most of the lodes, mine after mine having been closed down. It was consequently not possible in most instances to make any underground examination of the reefs. Mr. Gibson's report in many cases, however, gives much information as to workings which I have been unable to describe.

Fraser's Mine (British and Foreign Development Syndicate, Ltd.), G.M.Ls. Nos. 13, 29, 279, 505, 506.—As this mine has been fully described, with several diagrams, in Mr. Gibson's report it is unnecessary for me to repeat the description there given. Reference should also be made to the Report dated 11th June, 1907, of Mr. H. P. Woodward, F.G.S., Assistant Government Geologist, published in Bulletin No. XXXII of The Geological Survey, in which there is a more recent description of the mine with special reference to the project of testing the reef in depth by boring. The reef is a long and strong one, and appears to combine many features of the "shear zone" and "shattered zone" types of lodes with those of the "fissure vein" quartz reef as commonly understood. It lies conformably with the foliation of a belt of schistose diorite, which at times is seen to be highly silicified and transmuted to a laminated quartzite, very similar to parts of the ferruginous jasperoid lodes, and the main quartz veins occur somewhat irregularly through the belt of rock lying between the footwall of the "buck reef" and the hanging wall of Fraser's reef. Between these two main walls the

whole of the country appears to have been a good deal shattered, allowing the formation of fissure veins of quartz along the crevices produced by its fracture. The vein quartz is of the type usual in the more perfectly formed quartz reefs in the diorite country throughout our goldfields, being white or bluish white solid granular quartz with frequent dark coloured angular enclosures of fragments of diorite often much altered, and containing also a fair amount of iron pyrites. This reef at times contains massive occurrences of scheelite (tungstate of lime), in pieces of several pounds weight, which frequently accompany the ore richest in gold. The quartz is often in bands or ribs parallel with the walls, and these bands frequently differ considerably in gold value. In the oxidised superficial portions of the lode the weathered dioritic schist in the lode channel often carries a good deal of gold, rather probably a secondary deposition owing to the chemical reactions incidental to the process of weathering, but in the deeper parts of the mine the values appear to be fairly well confined to the quartz. Just below the oxidised part of the lode, however, I saw in one of the stopes some softened but unoxidised schist which was carrying very fair values in gold.

Though this mine is one of the oldest in the State, and has been very constantly worked, the main shaft is only sunk to the depth of 366½ feet below the surface. There is a great length of driving above this level, and the main Fraser's lode is often very large, being 20 to 30 feet wide in many places. It is owing to the long length of auriferous stone and the number and size of the ore bodies that the mine has been able to keep working so long at a shallow depth. On Fraser's lode there is a winze on the underlay (about 1 in 3 westerly) to 520 feet, and a level from it at 480 feet, but no work was going on at the time of my last visit below the 366 feet level. In the stopes over this level a fine body of quartz was being worked, up to 20 feet in width, yielding fair crushing ore.

There were 42 to 50 men on the Company's wages sheet and 22 tributers being employed, even though the mine was being worked on a much reduced scale from that which prevailed when it was in full operation. The recorded output of the mine to end of June, 1908, is 316,272.75 tons of ore treated for a return of 159,511.19 ounces of fine gold, equal to an average of 10.01 dwts. of fine gold per ton. This is a very creditable record, and justifies sanguine expectations as to the future of the mine. From one cause and another it has come to a stage now, however, when it requires energetic development in depth and an entire remodelling and modernisation of the surface handling and treatment plant, demanding a large capital outlay. Not having personal knowledge of the detailed assay values revealed by the lowest workings, I must express an opinion as to the prospects of success if such capital is obtained with some diffidence, but so far as I have been able to ascertain, there is not yet any sufficient cause for coming to the conclu-

sion that values will not continue to be found in depth if development is vigorously proceeded with, and it seems to me a very proper case for investment of the money required. The appearance of the ore at the 366 feet level gives great confidence that it will continue of fair value in depth, and as a mining enterprise the deeper development of the reef seems entirely commendable.

Fraser's South Extended G.M. Co., Ltd., G.M.Ls. 256 and 554.—This company's mine has been shut down since 1905 and the machinery removed. When I saw it in 1904 there were two principal shafts in lease 256 and levels had been driven at depths of 150, 200, 250, and 300 feet, the shafts being connected at 250 feet. The stone became rather poor, the crushings during 1905 yielding only very little over 4 dwts. of gold per ton, and there was considerable trouble with water, which was stated to be making at the rate of 287,000 gallons per day. The total recorded production from the mine is 18,433.55 ounces of fine gold from 43,747.68 tons of ore crushed.

On the same reef in lease 554 there is an old and apparently fairly deep shaft, known as the Day Dawn shaft, on the dump of which there is a quantity of schistose lode stuff containing veins and laminæ of quartz and a good deal of pyrites, which I was told contained gold. A rough sample taken by me was assayed in the Geological Survey Laboratory, yielding gold 3dwt. 15grs. per ton, and silver 2dwt. 22 grs. per ton.

The Fraser's South Extended reef is shown on the Geological Survey map as most probably a continuation of Fraser's reef heaved south-west by a fault. If so, it considerably increases the already long length throughout which Fraser's reef has been proved to carry payable gold, and strengthens the argument for its active development in depth.

Reward, G.M.L. 737, and *Perseverance*, G.M.L. 551.—Fraser's reef passes through these leases, but I have never had an opportunity of examining it underground in them. There is also another smaller reef in the Reward lately worked by Messrs. Hatt and Lang, lying east of Fraser's reef. When seen by me in 1903 it was only small, but contained some very rich ore; it has since been worked to 120 feet, but was not being worked at the time of my last visit. The output recorded in the "Mining Statistics" is 3,627.12 oz. of fine gold from 8,947 tons of ore crushed, but I am unable to say how much of this should be credited to each of the reefs.

Lord Cardigan, G.M.L. 613.—West of Fraser's reef there is a hill running N.W. and S.E. composed of several parallel bands of bold outcrops of the laminated quartzitic lodes. The most westerly of those on G.M.L. 613 is about 80 feet wide, and some work has been done on two veins 2 to 4 feet wide of rubbly and sintery quartz and brown oxide of iron, which appear to be formed in fractures of the main lode along its strike, subsequently to its first formation.

No one was working at the time of my visit. 913 tons are recorded as having been crushed for 232.93 ozs. of fine gold.

Haddon Mine, G.M.Ls. 552 and 611.—This mine also was at a complete standstill at the time of my visit. It is on the same belt of laminated quartzitic lodes as the Lord Cardigan, though probably on a more easterly line than the latter. There are two large open-cuts and a considerable amount of underground workings. In the open-cut workings it is pretty plainly to be seen that the ore has been formed in portions of the large jasperoid lode that have been shattered by some movement of the country subsequent to its first formation, there being numerous veins of quartz and ironstone intermingled through broken and jumbled masses of the laminated quartzite. There is much pulverulent brown iron ore in the auriferous material, and often the quartz is of cellular and sintery character, pointing to the ore being pyrites in depth.

The mine had its own battery, and a plucky attempt was made to handle what proved to average very low-grade ore. The recorded output from the leases to end of last June is 7,874 tons of ore crushed for 1560.50ozs. of fine gold, or barely 4dwts. per ton.

Golden Pig North, G.M.L. 670.—A little work has been done on this abandoned lease north-west of the Haddon on the same line of lode, 154 tons having been crushed for 28.90ozs. of fine gold.

Eureka Boulder G.M.L. 556, and *Eureka Boulder South,* G.M.L. 578.—On these leases there is another large laminated jasperoid lode running north-westerly, on which several small shafts have been sunk. but have been abandoned. Thirty tons crushed are recorded as having returned 7.22ozs. of fine gold.

Birthday Gift G.M.L. 663 (formerly *Rising Sun* G.M.L. 478) and *Northern Star* G.M.L. 560.—Several prospecting shafts have been sunk on this ground on two reefs, which from their position may be part of the Eureka Boulder line. No one had been working on them for some time when I saw them, and nothing could be seen of the underground workings. The returns appear to have been 53.71ozs. of fine gold from 185 tons of stone.

Auraria G.M.L. 579.—On this old lease there are some abandoned shallow workings on a reef of very dark-coloured quartz, said to carry a little gold. Fifteen tons crushed are recorded as having returned 4.45ozs. of fine gold.

Tarcoola G.M.L. 568.—This old lease lies considerably to the west of the foregoing ones, and from its position may be connected with the Transvaal group of lodes further south. There is an abandoned shaft which seems to have been sunk a fair depth, and round it such ore as is left appears to be schist, veined and interleaved with quartz and white quartz. I have been able to find a record of only 60 tons crushed for 8.29ozs. of fine gold.

Golden Rock G.M.L. 449.—There are some old workings on this abandoned lease from which 12.00 tons of ore are recorded as having been crushed for 1.73ozs. of gold. The veins of quartz seem closely connected with a dyke of dark-looking rock, which would attract a prospector's attention as being of unusual appearance. A piece of it was examined by the Government Mineralogist and Assayer, who reports:—

"The rock [1112] from the Golden Rock G.M., at Southern Cross, has been sectioned and found to be quartz diorite. It consists of a dark-green, strongly pleochroic hornblende, cloudy plagioclase without twinning, and some free quartz."

GREENMOUNT CENTRE.

The mines of the Greenmount group lie about three miles south of Southern Cross, and are on a series of parallel lodes running a little west of north. The lodes on surface contain much oxide of iron, which below water level changes to iron and arsenical pyrites. They seem to stand in very close relation with the lodes of the laminated quartzitic series, one of which is very well seen at the south end near the old Imperial lease (G.M.L. 591). From Mr. Gibson's geological map it appears rather probable that it is a continuation of the same belt of laminated quarzite which exists on the Ballast Pit Reserve on the railway line west of Southern Cross, on old G.M.L. 348. The Greenmount series appear to be the most westerly of the parallel groups of auriferous reefs worked in the neighbourhood of Southern Cross, with the exception of the small group at Blackbourne's.

Transvaal Mine, G.M.Ls. 536 (Transvaal), 712 (Blue Duck), and 720 (Cushie Doo).—The Transvaal reef appears to be the principal member of a group or "run" of nearly parallel lodes running about N. 20deg. west from the Drysdale lease, G.M.L. 757, on the south to the old Lord Roberts lease, G.M.L. 622, on the north, a total distance of over two miles, and which comprises also the "Sunbeam" (G.M.L. 550), "St. George" (now Golden Fleece G.M.L. 756), and several smaller lines of reef. Several of these in parts show a strongly laminated structure quite similar to that of the large ferruginous laminated quartzitic lodes of the district, and at the south end of the line, a little to the east of the old Imperial lease (G.M.L. 591) there is one of the large outcrops characteristic of these laminated lodes traceable for half-a-mile on nearly the line of the Transvaal reef. There is evidently here, as frequently elsewhere in the district, a very close connection between the auriferous quartz reefs and the laminated quartzitic lodes.

The principal workings of the Transvaal mine are on lease 536, where there is a main shaft equipped with winding machinery. At the No. 1, or 60 feet level, the lode has been driven along for about

660 feet to the south, and stoped mostly to surface above this level. The stopes are stated to have averaged about 7 feet in width, but the lode from wall to wall is often 15 to 18 feet in width. In the south end driving was discontinued when the ore became unpayable, changing to dark, silicious material, probably pyritiferous, in depth. North from the main shaft the No. 1 level has been carried 513 feet, and above it the lode has been stoped for 300 feet of this, being a big ore body as in the south end. At about 300 feet there is a disturbance and the lode narrowed to about 3 feet wide, of rather mullocky lode material containing bands of dark quartz. No crosscuts have been driven in this part of the level, and it is not at all clear if the full width of the lode is seen.

The No. 1 level was just above the permanent water level in the mine, and above it the lodestuff was very thoroughly oxidised. It was rather poor in gold, containing from 4 to 6 dwts. per ton. Below the water level the ore soon becomes highly charged with pyrites, principally arsenical pyrites, the oxidised material going nowhere below the 120 feet level, and the average values are stated to improve considerably. The mine assay book shows returns from the sulphide ore of from 3dwts. up to 2ozs. per ton, but mostly running from 8dwts. to 17dwts. The owners estimate that a valuation of the sulphide ore at an assay content of 45s. worth of gold per ton is below rather than above the average of this ore.

The No. 2, or present bottom level, is 145 feet from the surface, and at the time of my visit had been driven 130 feet south and about 100 feet north, showing a big strong body of ore right along. The ore is white quartz, highly charged with arsenical pyrites. It is somewhat banded, consisting frequently of a number of layers parallel to the walls The quartz is of very promising appearance, with the arsenical pyrites distributed well through it. In the stopes the presence of a small amount of copper in the ore reveals itself by occasional efflorescences of blue sulphate of copper. In the leading stope in the south end the lode is seen to be 18 feet wide from wall to wall. In the north end it has been taken out 8 feet wide, without exposing the walls. All through this level the lode shows a fine, strong ore-body. Where the walls are seen they are smooth, hard, and distinct, with every promise of permanency of the lode in depth. The underlay is very slight, the lode being nearly vertical.

The No. 2 level has been sampled lately by several parties examining the mine, and I have been given to understand that the results have shown a value in gold very consistently agreeing with the mine assays above mentioned.

The main shaft has small poppet heads upon it and winding is done with a two-drum geared winch. A Cornish pump raises the water, which is salt, and makes at the rate of 8,000 to 10,000 gallons per day. Close to the shaft is the battery, of 20 stamps, with

Gates' rockbreaker, elevator raising broken ore to ore bins, automatic feeders, tailings wheel, and cyanide treatment vats. The owners told me that when working the oxidised ore they were able to keep all costs of mining and treatment within 16s. per ton. The sulphide ore however proved impossible of treatment economically without roasting.

In Appendix I. to this report particulars are given, in his own words, of tests made at the mine by its metallurgist, Mr. C. Nardin, B.E., which show that after thorough roasting very fair extraction of the gold contents can be obtained by ordinary cyanide leaching treatment. Doubtless even better results could be got by fine grinding of the roasted material followed by agitation with cyanide solutions and filter press treatment.

To confirm Mr. Nardin's results a fairly large sample of what was considered average grade ore from the No. 2 level was taken by the owners of the mine and divided into three parts of about 1cwt. each. One of these was used by Mr. Nardin in his test No. 5, which gave an extraction of gold, after roasting, of 80.3 per cent., and a second was sent to Mr. E. O. Watt, of Davyhurst, who reported to the mine owners: "The ore was passed through a 700-mesh, roasted, and cyanided direct for six days, and gave an extraction of 86 per cent." The third portion of the sample was sent to the Mineralogist and Assayer at the Geological Survey Laboratory, whose report is quoted in full in Appendix No. II. hereto attached. From perusal thereof it is seen that in the sample dealt with by him the value of the raw ore in gold was 16dwt. 17grs. per ton and that there was a very little (0.010 per cent.) copper, while arsenic amounted to 26.09 per cent., equal to about 56½ per cent. of arsenical pyrites. The ore proved unexpectedly easy to roast thoroughly, the arsenic being reduced to a trace and sulphur to 0.25 per cent. An extraction of 82.6 per cent. of the gold was obtained by cyanidation. Bromo-cyanidation gave no better result and was much more expensive in chemicals. A chlorination treatment gave an extraction of 79.9 per cent. of the gold. The most important result is that which proves that the sulphur and arsenic can be thoroughly roasted out of the ore, as, if this is done, the extraction of the gold by cyanide treatment is no longer a matter of doubt. There is no reason why roasting results on a large scale should not be obtained in practice quite equal to those got in the laboratory, and with fine grinding and agitation of the roasted material with cyanide solutions the working extraction by cyanide treatment should be even better than the laboratory results by percolation. The roasting of this highly pyritiferous material will doubtless approach roasting of concentrates in point of cost, but can probably be done for not more than 10s. per ton when working on a large scale.

There have been proposals also to send the ore by train to the Smelting works at Fremantle to be smelted with lead ores from Nor-

thampton, but taking the cost of transport into consideration it is difficult to see how this could compete with treatment on the spot.

The white arsenic resulting from the roasting of this highly arsenical ore would have to be caught as much as possible in fume chambers, and would be a more or less marketable commodity.

In the Blue Duck lease according to the surface showing, the reef is small, but in the Cushie Doo lease a shaft has been sunk on stone 11 feet wide which is said to have returned about 6dwts. per ton on crushing. Very little work has been done however.

To the end of June, 1908, the Transvaal mine is recorded to have crushed 30,173 tons of ore for a return of 7,298.99ozs. of fine gold and 358.08 ozs. of fine silver, being at the rate of 4.8 dwts. of fine gold per ton. Though this has been sufficient, with great economy on the part of the owners, to enable them to pay their way, it is clear that below water level, where the reef and the country both become hard and solid, and where the ore requires roasting treatment, there is not much hope of success unless the mine yields a considerably higher grade of ore. So far as development at No. 2 level has gone there seems every reason to be sanguine that such higher grade of ore exists, and that the mine, when equipped with good reduction plant, will be able to give good payable results. The prospects at the present time seem to me to be very fair, there being a big strong good-looking reef with, so far as I can ascertain without actual sampling, good values in it, proved gold-bearing at the No. 1 level for nearly 1,000 feet in length, and it having been shown that the ore can be successfully treated at reasonable cost if properly roasted. In order to work to advantage, however, the mine owners require capital to enable them to install a roasting furnace and remodel their existing milling plant. To fully justify this expense, it would be very advisable to increase the amount of development underground by extending No. 2 level as rapidly as possible both north and south, and especially by sinking another 100 feet in the main shaft. If the values and size of lode found at No. 2 level are proved to persist to No. 3, the mine would be a very fine mining proposition. Any company taking it over at the present juncture would, in my opinion, be well advised to push forward this development work before spending much money on surface plant to make sure that the latter is fully justified. The case is therefore one for provision of a considerable amount of working capital, to be expended before much is expected in the way of returns.

In advocating what many may consider an unnecessary amount of expenditure in development prior to putting up plant to treat the large amount of ore already in sight, I am greatly influenced by a doubt which arises when comparing the value of the poor ore in the upper oxidised zone with that of the much richer heavily mineralised stuff at No. 2 level, namely, that the latter may be to a great extent a secondary enrichment which will not persist in depth. It is very

possible that much of the dense pyrites may be a concentration from the materials removed by oxidation and solution from the oxidised part of the lode, and also that the gold contents may have been similarly enriched. Prudence therefore demands that as soon as possible the shaft should be sunk at least 100 feet deeper, to see if there is any reality in this supposition. Should the values be proved to continue good, all would be well, but if there were any serious falling off the position would require reconsideration and still more outlay might be necessary before the mine could be regarded as sufficiently developed to justify any large expenditure in reduction plant. It is nevertheless already clear that there is a considerable amount of good ore in sight, with every reason to expect that the extension of the No. 2 level north and south will greatly increase the reserves, and it seems quite probable that active development might soon prove the existence of enough payable ore to justify immediately proceeding with erection of a new treatment plant.

In expressing the above opinions about this mine I am going on the owners' assay returns as shown by their books and their statements of the value of the sulphide ore together with information received as to the results of other samplings, but not on samplings done by myself. The time available for my examination of the district was much too short to allow of any sampling of individual mines, and unless sampling is systematically and thoroughly conducted—a process taking a long time—it cannot be relied upon, and therefore is not worth attempting. Any person whom this report might influence to invest in the Transvaal mine is therefore advised that he must satisfy himself by such other evidence as he can elsewhere obtain on the all-important point of value of the ore, and must take my report as subject to verification of the values upon which it is based. Assuming the correctness of the mine assays—and I see no reason to doubt them—the mine is a very promising proposition, likely to become one of the leading mines of the district. It seems certainly worth close examination by the skilled representatives of investors of capital in mining.

Transvaal North G.M.L. 754 (formerly the "Rand" lease 590).—Close to the north boundary of the Transvaal lease the latter's lode has been worked in this adjoining one. The recorded returns are only 48.49ozs. from 205 tons crushed, but I was informed on the ground that about 1,000 tons had been crushed for a return of about 3½dwts. per ton by amalgamation. The tailings were believed to contain more gold than was extracted by amalgamation.

Golden Fleece G.M.L. 756 (formerly "St. George" G.M.L. 564).—This holding lies south of the Transvaal leases, and a good deal of work has been done on a reef running parallel with that of the Transvaal, but about 200 feet to the east of it. A shaft has been sunk about 130 feet. The reef is rather small. Up to the end of last June 559 tons are recorded as having been crushed for 118.93ozs. of fine gold.

Sunbeam G.M.L. 550 and *Royal George* G.M.L. 565.—A gold-bearing reef has been found from end to end of these two leases, a total distance of 28 chains, and has been pretty well worked out down to the 60-feet level, water level being at about 80 feet. In the Sunbeam lease there is very little work done below the 60-feet level, but in the Royal George the shaft is down 150 feet. The reef runs about N. 15deg. W., and has only a slight underlay to the west, being nearly vertical. It has smooth, distinct walls 12 inches to 4 feet apart, and the vein stuff is mostly quartz. At the time of my visit 15 men were employed in the mine and battery, the latter being a five-head mill, with cyanide leaching vats. In the hard ground below water level the reef is somewhat small for profitable working at its low grade. The shoot of ore near the main shaft is stated to have been 4 feet wide down to the 57-feet level, and to have yielded 8dwts. of gold per ton by amalgamation, with tailings sands assaying 5dwts. per ton, from about 1,000 tons crushed. This shoot seems well worth sinking upon. To the end of June, 1908, these leases are recorded as having crushed 8,616 tons of ore for a return of 2,706.25ozs. of fine gold. The small size of the lode and its low average grade in gold have been much against its successful development.

The Sunbeam battery crushes for the public at 8s. 6d. a ton, or 10s. for small parcels, and has been of great assistance in this respect to the prospectors of the district. At the time of my visit (15th June, 1908) 2,472 tons of stone had been crushed for the public for 1,062ozs. 3dwts. 8grs. of unrefined gold, equal to 8.6dwts. of gold per ton. The tailings sands were stated to average about 4dwts. of gold per ton. The battery buys the sands at 2s. per dwt. for every dwt. over three, rising to 3s. for the seventh dwt. and 3s. 6d. for the eighth.

The mill crushes about one ton of ore per hour, with 98 to 100 drops of the stamps per minute, and uses about 34,000 gallons per month of fresh water from the Goldfields Water Supply. Ten cords of firewood are sufficient to run it 13 hours a day for a month. The cost of wood, water, and wages was given to me as £135 a month.

Messrs. Gilbert and McDonald have lately started working this reef to the north of the Sunbeam lease, selling their stone to the battery at 8s. 6d. per ton.

East of the Sunbeam reef there is a large parallel reef of laminated ferruginous quartz, which contains a little gold, but has not been thought good enough for working. It may be identical with the large ironstone reef seen further south on the old "Great Southern" lease (G.M.L. 713).

Great Surprise (formerly Great Southern) G.M.L. 713.—This mine has been abandoned for some time. There is a fairly deep shaft upon it, on the dump of which there is much pyritic material and white quartz of unpromising appearance. A large lode is seen

at surface of laminated ferruginous quartz, which seems to have changed in depth, according to the stuff visible on the dump, to pyritiferous schist. There are also surface workings on a cross vein cutting through the big lode, which seems to have been a fairly strong body of stone, and is said to have carried gold for a time. The mining statistics show 135 tons crushed for 23.48ozs. of fine gold, also 31.99ozs. of alluvial gold, and 3.38ozs. from specimens.

Greenmount Mines, N.L., G.M.Ls. 503, 535, 555, 757 (formerly "United Australia").—This mine has been worked on a fairly large scale for over three years past, having yielded to the end of June, 1908, 50,588 tons of ore, which gave 11,546.55ozs. of fine gold and 306.67ozs. of fine silver. The workings have been mostly in the oxidised portion of the reef, which is a long, strong lode, traceable on surface for about three-quarters of a mile on a course about N. 120deg. W. There are two principal levels opened from the main shaft, which goes down on the underlay of the reef at an inclination of about 70deg. from the horizontal. The underlay is to the westward. No. 1 level is 100 feet, and No. 2 133 feet vertically below the surface. No. 1 level has been driven about 850 feet north of the shaft, with branch drives amounting to about 200 feet, and 700 feet to the south. No. 2 level runs 400 feet south and 120 feet north. The reef is a large body of quartz, often carrying a good deal of oxide of iron, with smooth, distinct walls, but contains often a good deal of mullocky veinstuff besides the quartz. Though the walls seem very distinct the country behind them in the upper levels often seems much broken and disturbed, but hardly enough to enable it to be regarded as part of the lode "formation." The values in gold appear to be confined to the quartz. The lode is often up to 10 feet wide from wall to wall, and would probably average about 6 feet. The value in gold has been, unfortunately, very low, the above figures showing an average return of only 4.5dwts. of fine gold per ton crushed, and as the oxidised ore is nearly exhausted the prospects of the mine are not at present very promising. Just below the No. 2 level the reef becomes somewhat heavily charged with sulphides, principally arsenical pyrites, which rise above the level as it is driven to the south. As in the Transvaal reef there is a little copper pyrites present also, the oxidation of which causes efflorescenses of blue sulphate of copper. The improvement in value seen in the Transvaal mine when the sulphide ore was reached does not appear to obtain in the Greenmount, the pyritic ore being poor in gold so far as yet tested. With the increased hardness of the reef and of the country below water level and the necessity for roasting the ore to get rid of the sulphur and arsenic in it, the working expenses must increase very considerably, and unless ore of better value is found there seems very little prospect that the mine can carry on work in the sulphide zone. I am of opinion, however, that there are very fair chances of success by persisting in development of the reef, and would like to see the shaft sunk another 100 feet,

and some driving on the reef done from the bottom of it, before there is any thought of abandoning the enterprise.

The Greenmount mine has a fairly complete equipment of machinery for winding ore, and a battery with cyanide plant.

KENNYVILLE CENTRE.

The group of reefs found at Kennyville lie a little over three miles east of the Greenmount mine, the width of the belt of country which has here been found to be auriferous from Blackbourne's to Kennyville being nearly six miles. The Kennyville reefs appear to belong to a southern continuation of the most easterly series of the Southern Cross group of reefs.

Great Leviathan Mine, G.M.L. 570.—This mine has been worked on a fairly large scale, and is equipped with an excellent outfit of machinery on surface, comprising a fine set of poppet heads, a winding engine, air compressor, and rock-drilling plant, and a 10-head battery. Up to the end of June, 1908, 14,526.85 tons of ore are recorded as having been crushed for a return of 5,923.31ozs. of fine gold. A branch of the Goldfields Water Supply pipe line has been laid to this mine.

There is a very large outcrop of quartz on the surface, on which a large open-cut excavation has been made. The gold, however, appears to be mainly in certain veins and layers in the quartz mass, and not at all evenly distributed through its bulk. The main shaft is sunk to the 260-feet level, but at the time of my visit was full of water up to about 6 feet below the 130-feet level. The principal work done in the mine has been carried out by the late owners, the Northern Blocks Syndicate, Ltd., but the property has now passed into the hands of another syndicate composed of the firm of machinery merchants, who purchased the plant, and a party of working miners. At the time of my visit the latter had only started work a few days, and had hardly got into working order. Consequently, I was not able to examine the underground workings to advantage. There is a long drive south at the 130-feet level, on a course about south-east, which appears to be about the strike of the gold-bearing veins. These dip nearly vertically, but there are also numerous cross veins and leads running about north and south and dipping flatly to the westward, which cut the north-west and south-east veins, and probably fault them. The cross-veins are poor in gold, and are most likely of later formation than the auriferous ones which they cut through. They often have smoothed walls, with clayey surfaces, suggesting that there has been movement of the wall rock upon them.

The vein of good stone worked in the open cut was followed down to the 130-feet level and below it, in the form of a flat pipe-like ore-shoot, dipping rapidly westward. The good stone was, I am

told, 18 inches to 2 feet in width, but became very small in the hard greenstone (diorite) country at the 260-feet level. I was told, however, that though small, some of it was of good value there, up to 3ozs. of gold per ton.

There are some cross-cuts at the 130-feet level, but these do not reveal any true walls to the large mass of quartz and shattered country in which the workings have been excavated. The lode, as a whole, appears to be a large shattered zone of rock through which much quartz has been deposited, and much cross-cutting from solid country on one side to solid country on the other is required to enable it to be properly understood. It seemed to me, during my short and necessarily imperfect examination of the mine, most probable that the auriferous veins were of earlier date of formation than the bulk of the white quartz seen, and very possibly they at first formed a group of smallish parallel reefs following a zone of fracture and faulting of the country. Subsequently it is probable there was a repetition of the faulting movements of the country, reopening the old line of weakness and shattering the belt of ground in which the veins lay, this shattering being followed by deposition of large quantities of poor, white quartz. The faulting stress being applied at a different angle from that which caused the original fissuring, might be the cause of the formation of the cross-veins running north and south, and of their faulting the auriferous veins. It seems pretty clear in the stopes above the 130-feet level that the cross-veins *do* fault the gold-bearing ones, and the so-called ore-shoot or pipe seemed to me rather a section of an older vein lying between two parallel cross-veins than a true shoot. I should, therefore, strongly urge search by frequent cross-cutting for other portions of the same vein, which may have been cut off by faulting by the cross-veins.

The new owners were at the time of my visit working about 300 feet S.E. of the main shaft in a prospecting shaft which they were sinking. They have good gold in two small vertical veins, and from "floaters" found to the east of the big quartz outcrop they are hopeful of finding another vein there somewhere also. They think that by closely following the gold-bearing veins they will be able to make a living and may be able to reopen the mine on a larger scale as the position and relation of the auriferous veins with regard to the valueless quartz become more clearly visible. In confining themselves at first to dissecting out the gold-bearing veins it seems to me that they will be following a thoroughly sensible policy, as there is much reason to believe that these will be found to be independent ore-bodies with a more or less definite position and occurrence of their own in the bigger bulk of poor quartz. Unless the latter contains enough gold to pay for mining and milling the less of it is sent to the mill the better.

Cornishman, G.M.L. 776.—The reef in this lease runs about N.W. and S.E. with slight underlay to S.W., and from its position

may be a continuation of the Great Leviathan reef. To the north of the workings there is a reef running N. 10 degrees W., with slight westerly underlay, which appears to run into the first-mentioned one, but it is doubtful if they are or are not separate reefs.

The main shaft is down 120 feet in weathered diorite country, and there is a small crosscut at 90 feet, and a considerable amount of driving at the 60ft. level, to which depth there are two or three other shafts. At the 60ft. level the hanging wall country seems much shaken and disturbed, but hardly enough to allow it to be considered lode matter, though it contains numerous veins of quartz. Very possibly there has been some shattering of the country after the reef was found, in the same way as above suggested in the case of the Great Leviathan. At the 60ft. level the reef was not large, about six to 18 inches as a rule, but has been of good value, 104 tons crushed to end of June, 1908, having returned 182.01 ozs. of fine gold. The walls are distinct and smooth. The best part of the ore-shoot was 150 feet long, but the ore was fairly good for another 150 feet as well. In the bottom level the reef is 4 feet wide, carrying fair stone.

A little work has been done on the north reef, but though it contains gold it is hardly worth working under present conditions.

Pendrea, G.M.L. 575.—On this old lease a good deal of shallow work has been done on the outcrop of a laminated quartzitic or jasperoid reef, striking N. 22 degrees W. and dipping westerly. The banded reef itself is a large one, but the two veins in it which appear to have been worked are up to about 4 feet in width, and consist of friable quartz much intermixed with brown oxide of iron, quite similar to the auriferous veins in many other of the jasperoid reefs of the district. Several crushings are said to have been taken out, giving returns of from 3 to 7 dwts. of gold per ton, but the only officially recorded figures are 25 tons crushed for 5.22 ozs. of fine gold. The western side of the reef appears to be hard blue diorite, but to the east the country appears to be softer and weathered to some depth.

Close to the southern end of lease 575 on the adjoining ground to the south there are some shallow workings on a clayey lode of weathered shaly laminated dioritic material containing very little quartz or iron oxide, but probably belonging to the same laminated jasperoid lode above described, and representing a portion of the original sheared diorite from which it was formed but which has escaped transmutation into silica and iron oxide. A crushing of low value is said to have been taken from this place.

Lime Kilns, M.Ls. 4, 5, 6, and 7.—About a mile and a-half S.S.E. from Southern Cross on the direct road to Parker's Range, there is an extensive shallow deposit of impure limestone, mostly in the form of globular concretionary gravel, but partly also in layers of more solid material which appears to have been laid down as a

travertine deposit. The underlying country is hard blue greenstone (diorite), and the concretionary pebbles often contain fragments of greenstone as a nucleus. A certain amount of this limestone has been burnt for lime, and the gravel is also used for making roads. The concretionary pebbles range from about ¼ inch to 3 inches in diameter, and are often very perfectly spherical. Two samples taken by me have been analysed in the Geological Survey Laboratory with the following results:—

No.	Private Mark or Description.	Result of Analysis.	
1107C	Concretionary Limestone	Silica	11·18 per cent.
		Alumina	2·53 „
		Ferric Oxide	2·66 „
		Lime	42·69 „
		Magnesia	1·94 „
		Phosphoric Anhydride ...	0·11 „
		Organic Matter CO_2 and HO_2	37·89 „
		Alkalis and loss	1·00 „
			100·00 „
1108C	Massive Travertine ...	Silica	8·79 per cent.
		Alumina	2·30 „
		Ferric Oxide	1·33 „
		Lime	40·90 „
		Magnesia	5·52 „
		Phosphoric Anhydride ...	Minute trace
		Organic Matter CO_2 and HO_2	40·67 per cent.
		Alkalis and loss	0·49 „
			100·00 „

There is a fair quantity of organic matter in each sample.

The Mineralogist and Assayer also examined the material as to its cement-making capabilities, and reported:—

"Product of Burning.—The Cementation indices (Eckel) are:—

1107	0.79
1108	0.58

Since these are well below unit value it follows that the burning of the rock would yield a product containing a considerable amount of free lime, and therefore to be classed as a hydraulic lime. In order to obtain a good hydraulic cement (working with a mixture with an index of 1.2), about 10 per cent. of ordinary clay would have to be added to 1107 and 15 per cent. to 1108."

The origin of this deposit offers a geological problem of a good deal of interest, but which need not be here discussed.

BLACKBOURNE CENTRE.

The mines at Blackbourne, about 1¼ mile W.S.W. from the Greenmount mine, have not been worked for some years past except for occasional short trials by prospectors. The leases are recorded as having produced 226.88 ozs. of fine gold to the end of June, 1908, from 796 tons of quartz crushed. There are at least three parallel reefs lying close to one another, one of the outcrops showing a big body of quartz. They run about N. 10 degrees W. and underlay to the eastward. There was a battery on the ground some 13 years ago, so the above recorded returns probably by no means give the whole of the gold which has been obtained. The dumps show that a considerable amount of underground work must have been done.

These reefs have apparently been very poor, but there seem fair chances that someone may yet find payable ore in their vicinity, as they are not by any means barren.

MT. RANKIN CENTRE.

Mt. Rankin is rather a prominent hill nearly 8 miles S.W. from Southern Cross, which shows a precipitous scarped face on its eastern side. Several leases have been taken up on it, but no work has been done for some time past. The steep face of the hill is formed by a large lode of laminated jasperoid quartz with much brown iron ore through it, running N.N.W. and S.S.E. and dipping eastward about 60 degrees. A short tunnel has been driven into the hill, a distance of perhaps 80 or 100 feet, in ferruginous laminated weathered diorite, passing through a fairly well-marked vein of sintery quartz and oxide of iron about 4 feet wide lying in the foliation of the laminated material. On this a shaft has been sunk, but I am not aware with what results. Some of the lode matter looked fairly promising.

At the foot of the hill on the west side several small shafts have been sunk and a good deal of quartz raised. It is clear from the dumps that there exists a wide lode of "shear-zone" type, but it does not appear to have been greatly shattered again after its first formation, and so seems to have missed the opportunity of having any considerable later impregnation with gold, as was most likely the case with such other of the similar lodes of the Yilgarn Goldfields as have been worth working for the precious metal.

The official returns to end of June, 1908, show for this centre 3.84 oz. of fine gold obtained from alluvial workings, 5.20 oz. from specimens dollied, and 69.50 oz. from 252 tons of ore crushed.

HOPE'S HILL CENTRE.

The Southern Cross group of reefs is found continuing to the north-west at Hope's Hill, about 4½ miles distant, close to the contact of the diorite country with the granite.

The Hope's Hill Mine (G.M.Ls. 19, 52, 360, 480) has been closed down for some time now, but was seen by me in 1904, shortly before work ceased. The lode is a very large low-grade ore body, striking N.W. and S.E., which has been worked extensively on surface by open cutting, and underground down to the 160ft. level, below which it became unprofitable to work. There are four levels, the lowest being some 300 or 350 feet below surface. The ore body has been driven along for about 1,800 feet at the 160ft. level, and has been taken out in places as large as 30 feet in width, averaging probably between 15 and 20 feet wide. It consisted of rubbly quartz and clayey and talcose material, being probably originally one of the laminated quartzitic type of lodes which has been subsequently shattered and impregnated with gold in a second period of lode-forming activity. The returns at the time of my visit in 1904 were from 3dwt. to 3½dwt. of gold per ton, and all expenses, except development, were covered by 12s. 6d. per ton. The total recorded returns from this mine are 31,671.83ozs. of fine gold from 124,825 tons of ore treated.

Below the 160ft. level the lode became hard, and more expensive both to mine and to mill, and could not therefore be treated profitably at the values recoverable from it. It had a well-arranged battery and treatment plant, and winding machinery, all of which have been removed since work was abandoned.

Lately there have been a good many prospectors searching in the neighbourhood of the Hope's Hill mine for other lodes, and I have little doubt that they will have more or less success, as the surrounding country appears favourable for their occurrence.

JACOLETTI CENTRE.

The belt of dioritic country passing from Hope's Hill through Southern Cross and Greenmount continues on a south-easterly to south-south-easterly course to Jacoletti and Parker's Range, with granite both east and west of it. Where mines have been opened up it is soon seen that though the laminated jasperoid lodes are not quite so much in evidence as at Southern Cross they are still a very characteristic feature of the auriferous belt, and very closely connected with the gold-bearing deposits, several of which are in them. More than at Southern Cross, however, the southern portion of the auriferous belt shows ore deposits of the "shattered zone" type, with quartz veins of often very irregular shape ramifying through wide "formations" of shaken and shattered country. The diorite rock is very usually schistose, with lamination fairly parallel with the general trend of the auriferous zone and of the enclosed lodes.

Christmas Gift, G.M.L. 656.—This lease lies about four miles N.W. from the Jacoletti and Marvel Loch group, and after being abandoned for over a year had been taken up again only a short time before my visit. A shaft has been sunk 100 feet deep, and at the

bottom there is a crosscut eight feet in length to the reef, which is there very small and has not been driven upon. At 45 feet the reef has been driven along to the S.E. for a short distance, and also a little way N.W. of the shaft. On the S.E. side of the shaft a short shoot of quartz, about 20 feet long and up to 6 feet wide, has been worked out above the 45 feet level, yielding some very fair ore, 452 tons crushed having returned 325.83 ozs. of fine gold. The new owners are sinking a winze from surface to enable them to work this shoot lower down, and propose then to return to the main shaft and work from the 100 feet level. There is a solid but short block of stone underfoot at the 45 feet level, and if it proves of good value the party will soon be able to knock out a fair amount of stone. The quartz vein has smooth distinct walls, but much of the lode matter between them is soft broken-up country. Near the shaft where the vein got very small some very rich ore has been found at times in greenish clayey material in the vein.

Another shaft sunk about 200 feet to the S.E. of the first was put down 40 feet, and a crosscut was driven from it without cutting any ore of value. The ore-shoot, so far as yet seen, has been short.

At the 45 feet level of the main shaft a crosscut has been driven to the south-west about 66 feet, passing all the way through a laminated "formation" of quartz veins, iron oxide, and clayey material. This is lodestuff, and evidently a very large "formation" exists here of which the quartz vein worked is only a small part on the eastern wall. The crosscut is said to have shown by assay small values in gold all the way along its course, which would indicate that the large "formation" itself deserves careful prospecting. It belongs to the same class of lodes as the "Never-Never" and "Great Victoria" found further south, and any payable values which it may contain will probably be found in the more broken-up portion of it as in these.

The crosscut passes through a small pegmatite dyke (locally known as a "mica" bar) which appears to penetrate right through the lode formation, in this resembling the similar dykes in the "Never-Never," "Exhibition," "Golden Cube," and "McIntosh" mines.

Exhibition, G.M.L. 753.—Several small shafts have been sunk on this lease on a large auriferous "formation" the extent of which is not by any means clear. It consists of white soft kaolin with veins of quartz and rubbly quartz through it, and may be much altered diorite but seems more likely to be a felsitic dyke. It very strongly reminded me of the Haveluck mines at Meekatharra. A little tourmaline occurs in the "formation," givng support to the belief that it is of felsitic nature. In the 100ft. level of the principal shaft the "formation" is penetrated by a flatly dipping "mica bar" or pegmatite dyke, about three feet wide, evidently of much later date of formation, and which does not appear to affect the gold

values. The bottom of the shaft is in soft kaolin country but nine feet west of it the crosscut reaches the wall of what is considered the "lode" for practical purposes, which is here a mass of rubbly quartz and kaolin about 18 feet wide. On the west wall of this, which runs N.N.W. and S.S.E., a short drive has been made each way from the crosscut. In the north end of this drive there were 18 inches of ironstained rubbly quartz, said to be of fair payable value. In the south end the pegmatite dyke was cut, and beyond it there were above six feet in width of ironstained quartz estimated by the owner to be worth about 5dwts. of gold per ton. These workings are on the same lode as is worked at the 40ft. level above, and show that there is an underlay of its footwall to the west of nine feet, in 60, the wall being in the side of the shaft at 40 feet.

East from the shaft at 100 feet a crosscut has been driven 70 feet, the first 42 of which are through laminated kaolin with a little quartz through it in veins. At 42 feet a clayey "formation" has been cut, and driven along a few feet.

At the 40ft. level the lode of quartz and kaolin is on the west side of the shaft, and is over 20ft. wide. The footwall runs about N.N.W. and S.S.E. 27 feet north of the shaft the quartz is cut off short by a smooth-walled slide which crosses it almost at right angles dipping 80deg. S.S.E. This also cuts off a hanging wall branch of the lode on which a separate drive north has been made. The footwall drive is continued 20 feet through the slide in soft, white kaolin very free from quartz. This would be worth trying as material for making fire-resisting bricks, though probably too much stained with iron for any pottery purpose.

South of the shaft the lode has been followed for 69 feet, the drive passing diagonally through it from the footwall to the hanging wall, and a drive has been then carried back north along the latter to the slide. Opposite the shaft in the hanging wall drive a crushing of 60 tons is stated to have returned 18dwts. of gold per ton, and further south another of 230 tons gave 96 ozs. of smelted gold, or a little over 8dwts. per ton. On the footwall side near the shaft a crushing of 80 tons is stated to have given a return of about 4½dwts. of gold per ton. The owner informed me that from 1,400 to 1,500 tons had been crushed altogether from the mine for a return of about 22s. per ton on the average, with tailings assaying 2dwts. of gold per ton, but the official records to 30th June, 1908, only show 549 tons crushed for 148.09 ozs. of fine gold, being an average of 5.4dwts. of fine gold per ton.

This mine is still too little developed to enable much to be said with any confidence about its future prospects, but it has been shown that there is a fairly large body of low-grade ore in it, and it seems to be one of the series of large auriferous "formations" characteristic of this district, so there is good reason for opening it up extensively and giving it a thorough prospecting test.

Firelight, G.M.L. 762 (Application).—A little to the north of the Exhibition lease some work has been done in what appears to be the same or a similar white "formation" of kaolin and quartz, but no one was working on this and I did not hear what results had been obtained.

About 10 chains further north there are two shafts from which the weathered spoil thrown on the dump seems of more dioritic character, with quartz of reddish tinge.

Marvel Loch G.M. Coy., N.L., G.M.Ls. 714, 723.—This mine has attracted a great deal of attention of late, and is being worked by a Company who employ 15 to 20 men in it. There are three principal shafts, sunk to 100 feet, 150 feet, and 200 feet levels respectively. The latter is equipped with a winding winch and small boiler. From it at the 200 feet level a large amount of driving and crosscutting has been done, proving that there are several gold-bearing ore bodies runing north-westerly in a wide shattered zone of country. One crosscut runs north from the shaft, all through more or less broken country with frequent irregular veins of quartz, and has cut two fairly defined ore bodies several feet in thickness from which payable assay returns are stated to have been obtained, and one of which has been followed to the N.W. over 50 feet. No. 2 lode was stated by the manager to assay 25s. per ton in gold for the first 27 feet driven in it, 6s. for the next 12 feet, and 20s. for the last 12ft., and No. 1 lode gave 14½dwts. of gold per ton across a width of 10ft. The ore in these is dioritic schist much impregnated with quartz and pyrites, very similar to the schistose ore in many of the Kalgoorlie lodes, together with a good deal of fairly pure quartz. Small assay values in gold are also said to be obtainable right across the width of the shattered zone, in the dioritic country passed through in the crosscuts. The country at this depth is no longer oxidised, but there is hardly any water. The crosscut at the 200ft. level has also been carried S.W. from the main shaft about 95ft. to cut the "Boulder" lode, which was a more defined vein worked from the "Boulder" shaft at the 100ft. level. This is a well-defined quartz reef with smooth distinct walls, running north-westerly and with very little underlay, of width from 6 inches to several feet, and has yielded a good deal of ore of good value. The "Marvel Loch" shaft according to the manager's plan is about 320 feet N.N.W. from the main shaft and has levels at 82ft., and 150ft., with a winze from the latter to 200ft. From this another fairly well-defined north-westerly lode has been worked with good results. A crosscut N.E. from this shaft shows however that there is still more lode matter in that direction, passing for a considerable distance through laminated schist, oxide of iron, and quartz, said to contain a little gold all along the crosscut. This laminated lodestuff appears to belong to a lode of the same type as the other laminated jasperoid reefs of this district.

Very little stoping has yet been done on the reefs, most of the ore crushed having been broken in the course of development work. To 30th June, 1908, the official record shows 1,956 tons crushed for a yield of 1,459.15ozs. of fine gold.

Without very thorough sampling, especially of the schistose lodes at the 200ft. level, it is impossible to form a very decided opinion about the prospects of this mine, but from such information as I have been able to obtain there appears to be good promise of a successful future for it if well opened up. A large amount of development is plainly necessary to thoroughly prove the various lodes that have been found, and a good deal of outlay seems therefore inevitable if the mine is to be worked on a considerable scale without much delay.

Want of water is a serious trouble. Domestic and boiler fresh water supplies are obtained from the Government tank in the granite rocks less than a mile to the north of the mine. This tank, however, holds only 50,000 gallons when full, so is not a reliable supply in long continued dry weather, and at times water had to be carted from Southern Cross. For crushing purposes the mine has as yet no supply of salt water, so it is advisable to sink the shaft another 100ft. or more as soon as possible, in the hope of finding a supply as well as for further developing the mine. In a large shattered zone of rock like this there is great likelihood of finding a good deal of water when the shafts are carried well below the level of the lake country in the low-lying flats to the eastward of the auriferous belt.

Eveless Eden, G.M.L. 717.—I did not see this reef underground, as there had been no work done for some time, and the present owner had no more than a few hours taken charge of the mine when I visited it. There are two shafts, one down 110ft., the other somewhat shallow. In the latter a strong quartz reef is seen at surface, but is said to be poor in gold and has not been much mined. In the main shaft some very fair ore was obtained, and there is said to be gold in the bottom. The reef runs N.N.W. and S.S.E., and from the dump I take it that there is a good deal of schistose dioritic lode-stuff as well as quartz, probably part of the big "formation" passing through the Marvel Loch.

The Mining Statistics show 622 tons of stone treated from this lease to 30th June, 1908, for 349.17 ozs. of fine gold.

Jacoletti G.Ms., Ltd., G.M.Ls. 490, 517, 558.—This mine has been working for several years, and has winding machinery and a fairly well-equipped 10-head battery and cyanide plant.

The south shaft, about 400ft. S.E. from the main one, is down about 100ft., at which depth the reef has been driven along for a considerable distance north and south. At this level the ore-shoot which has been worked lies south of the shaft, and is about 70ft.

long. It has been taken out up to 6 and 8 feet wide in parts of the stopes, but is usually much smaller, and was rather small in the level itself. The stone is an amber-coloured quartz, with a little enclosed pyrites, and stains of copper sulphate on the walls show the presence of small amounts of copper pyrites. The quartz occurs in lense-like masses between smooth hard walls of diorite, the lode being a distinct fissure-vein. Outside the shoot the space between the walls is filled with laminated crushed diorite, but the gold values are stated to be confined to the quartz. In the south face of the level the lode-stuff is of laminated jasperoid character. There are very numerous leaders running into the walls, but no crosscutting of importance has been done. The course of the lode is about N. 40 degrees W., and there is a very little underlay to the east. Preparation was being made at the time of my visit for sinking a winze on the ore-shoot below the 100ft. level.

To the south and south-east from the south shaft gold has frequently been found in "floaters" on the surface, and a good deal of shallow trenching has been done without definite results. Quartz veins are numerous, but the auriferous ones from which the "floaters" have come have as yet failed to be discovered. There is every appearance of there being a large shattered zone "formation" lying east of the Jacoletti reef, and very probably the latter is on the main footwall of this.

The main shaft is sunk on the underlay of the reef to a depth of close on 300 feet, at which level the ground is very hard diorite. Near the shaft at the bottom level the reef is 2½ feet wide, of hard poor quartz, but going southward values up to 2 oz. per ton were obtained, the width of the ore-body being however only 6 to 18 inches. The walls are hard laminated diorite, often much charged with sulphides and carrying numerous ramifying veins of quartz, supporting the idea that the reef is only portion of a much larger lode "formation" lying to the east. In the south end of the drive, over 100 feet from the shaft, the reef is of laminated jasperoid character. The drive north goes in about 70 feet, the vein in it having been small, but in the face the vein-stuff has become softer and mixed with clay, looking rather promising for a make of quartz if continued. There is very little water in this mine at the bottom level, but this is probably due to the great tightness of both country and reef.

At the 100ft. level there is a drive south for probably between 200 and 300 feet, the end being said to be about 100 feet from the end of the north drive from the south shaft. Outside the ore-shoot the lodestuff is very regularly laminated dioritic schist with very little quartz, showing that the reef has been formed along a line which was in the first instance one of powerful shearing stress. Probably the quartz lenses were formed at a somewhat later stage when actual faulting movement along the line of shearing had de-

veloped spaces in which quartz could be formed. The ore-shoot at the 100ft. level was taken out 6 to 8 feet wide. The drive runs about 40 feet to the north of the shaft also.

About 400 feet east of the main shaft is the Jacoletti East shaft, which has been sunk about 50 feet. Here we clearly see a part of the shattered zone "formation" above mentioned as lying east of the Jacoletti reef. The crosscut at the bottom of the shaft shows a large jumbled body of quartz and mullock over 15 feet wide, without any defined walls, and the whole of the shaft seems also to be in much shaken and disturbed lode matter. There is a little gold in this shaft but the ore is rather poor.

From comparison with other reefs of the district it is pretty clear that the Jacoletti vein which has been worked in the main workings is very closely connected with the much larger "formation" lying east of it, and prospecting of the latter by crosscuts seems very advisable. Crosscutting could be carried out at the 100ft. level much more cheaply than in the harder ground deeper down, and would probably serve just as well to locate any ore-bodies lying parallel to the Jacoletti reef.

To 30th June, 1908, the Jacoletti leases are recorded to have yielded 5,991 tons of quartz returning 3,239.96 ozs. of fine gold.

McGrath and Party, P.A. 77.—To the north-east of the Jacoletti leases three shafts have been sunk on this Prospecting area, one an old one, about 80 feet deep, and two more recent ones about 35 feet deep. They are in broken country with disturbed quartz veins, carrying some gold but rather poor, and which probably are part of the large lode "formation" seen in the Jacoletti East shaft. Some of the quartz carries a large amount of scheelite (tungstate of lime). Fifty-six tons have been crushed for 11.52 ozs. of fine gold.

Alpha, G.M.L. 774.—This is probably on the same large lode "formation" as McGrath's P.A., the workings showing a big clayey body of disturbed country with several quartz veins through it. The main vein worked upon is from a few inches up to 18 inches wide, and runs N.N.W. and S.S.E. with underlay to the west, and has been sunk upon about 80 feet altogether, in whitish laminated kaolin country which may be dioritic but, as in the Exhibition lease to the east of this, seems more likely to prove felsitic. A crosscut has been driven 117 feet to the west at the bottom level, all through laminated country of lode-like character. In the end a large pegmatite dyke is cut.

The only crushing recorded from the Alpha lease to 30th June, 1908, is one of 34 tons which returned 26.19 oz. of fine gold, but the owners of the mine told me that previous owners had crushed 100 tons for a return of about 16 dwts. per ton as well.

Mountain King, P.A. 109 (Hoffman's).—There was some nice-looking stone at grass at this mine, which is about 12 chains N.W.

from Donovan's Find (G.M.L. 768). A shaft has been sunk 60 feet partly in whitish kaolin country, and a drive made to the S.E. 150 feet, on the lode, which was 8 feet wide for 15 feet but then gave out. It also got small when followed to the N.W. Sixty-nine tons from this mine returned 59.99 oz. of fine gold.

Donovan's Find, G.M.L. 768.—This lease lies 1½ mile S.E. from the Marvel Loch mine, but seems likely to be on the southerly continuation of the same large lode "formation." The reef that has been worked runs N.W. and S.E. and underlays a little to the west. The main shaft is down 137 feet but there is a winze from the bottom level 40 feet deeper. The reef is cut by a slide, but has been found again on the other side of it, the displacement not being serious. The ore-shoot worked is about 100 feet in length and often 8 to 12 feet in width. There are several parallel well-smoothed walls, and outside of the ore-shoot the lode is composed of laminated quartz veins and clayey matter. About the 40ft. level a crosscut has been run out 40 feet to the N.E. through somewhat laminated clayey country, but without finding any true defined lode-wall. It seems therefore that here again there is one of the large lode "formations" so common in this district and that the ore-body is a lenticular occurrence of quartz in it. So far as I could ascertain very little gold has been found in any of the lodestuff but the quartz.

The mine was employing 18 men at the time of my visit, and to end of June, 1908, has crushed 780 tons of ore for a return of 1,083.82 oz. of fine gold. The want of a water supply is very severely felt.

Lee's P.A. 129.—This lies south-east of Donovan's Find, and on it a shaft has been sunk 80 feet on a vein of quartz up to 3 feet thick, running a little west of north, in whitish kaolin country. At the bottom of the shaft the reef has been followed 60 feet north and 30 feet south. The stone in the paddock was expected by the owners to give an ounce per ton on crushing.

Frances Furness, G.M.L. 779.—This lease has a strong reef running N. 10deg. W., with slight underlay to the west, about 8 feet wide in the workings near surface. It has well-marked walls, and the veinstuff is mostly quartz, with some clayey matter. Shafts have been sunk to 50 feet and 80 feet, and a little cross-cutting has been done, but in both the ore was poor except near the surface, where some very fair ore was got. 274 tons are recorded as having been crushed to 30th June, 1908, for 147.90ozs. of fine gold. The charges were 10s. for crushing, 3s. 6d. for carting, and 3s. 1d. for water while working, making 16s. 7d. per ton.

To the south-west of and adjoining the Frances Furness lease, another lease has lately been applied for on a large ironstone outcrop running about N. 20deg. W., and underlaying a little to the west. A little gold has been found in this, but at the time I saw it no mining work had been done on it. The outcrop is somewhat

laminated, and consists of oxide of iron and quartz. There is said to be a similar outcrop about a mile to the south on about the same line. These occurrences serve to demonstrate the persistence of one or more long lines of large lode "formation" passing more or less north-westerly through all this part of the district, from the Christmas Gift down to the Great Victoria.

Never Never, G.M.L. 665.—The large lode worked in this lease appears to lie to the east of the main zone of lode "formations" just mentioned, and may be a branch from it; this view of it being rendered more probable by the fact that it has a much more westerly course than those previously described, its average strike being about west-north-west and east-south-east. The lode is a big "formation" of strongly laminated quartz, 30 feet wide in the bottom level cross-cut of the mine, and probably much wider from main wall on one side to main wall on the other. In parts of the mine the lamination of the quartzitic-looking material, of which the lode is generally composed, is very regular, and in these parts the values in gold are poor. In the parts of the lode which have been worked the laminated lode-matter appears to have been much shattered subsequently to its first formation, blocks of it lying jumbled one against another at all angles, and the crevices have been more or less filled with sintery quartz and oxide of iron, with often a good deal of kaolin. It seems pretty clear that the original laminated lode was a wide shear-zone in the diorite country along which the schistose diorite became transmuted into quartz, as a consequence of hydrothermal or pneumatolytic action. At a later stage the lode so formed was disrupted by some earth-movements and portions of it much shattered, and in these further mineral-forming action went on resulting in the deposition of ore bodies.

The Never Never lode very strongly reminded me of the St. George lode at Mount Magnet, which appears to be a quite similar ore-body, constituted from the much shattered and re-mineralised portion of an older lode of laminated quartz and jasper.

The mine has been worked by large open-cuts down to a depth of 50 or 60 feet, and in the west end it has been also opened underground from a shaft at 70 feet and again at 115 feet. At the bottom level the lodestuff is still thoroughly oxidised, and contains a great deal of brown oxide of iron. It has been driven along for a distance of about 60 feet, yielding ore of fair milling value on the average, and occasional pieces which assay very well. The average assay value for 60 feet, 9 feet wide, was said to be 16dwts. per ton. The owner seemed much pleased with the results he was obtaining in this drive at the time of my visit. From the bottom of the shaft a cross-cut south goes through 30 feet of quartz and oxide of iron, carrying good values, said to average 9.8dwts. of gold per ton for the full width of the lode, and then passes into laminated broken diorite, which becomes harder and less disturbed further in. The

south wall is considered the hanging wall. The foot wall is also diorite. Between the 70 and 115-feet levels the shaft passes through a pegmatite dyke ("mica bar"), 20 feet thick, which penetrates through the lode, but does not appear to have any effect on its value. The open-cut workings are 300 to 400 feet in length and 15 to 30 feet wide, and the plan of them resembles a boomerang in shape, the strike varying from east and west to north-west and south-east, with a general average of about west-north-west and east-south-east. The "formation" has been traced on surface some distance to the east.

The mine has a good 10-head battery electrically driven, with rock breaker, elevator, tailings wheel, and cyanide leaching vats. Electricity is used as power throughout the plant, electrically-driven hoists being used for winding and similarly actuated pumps for raising water to the battery and handling the return water from the tailings dams. The supplies of salt water for crushing are pumped a considerable distance from a well, and from the lake lying over a mile to the east of the mine. The consumption of fresh water was given to me as 7,000 gallons a week, the provision of a regular supply of this essential being one of the greatest difficulties of the task of the management of the mine. The battery crushes about 1,200 tons of ore a month, using screens of 900 holes per square inch, and has done a lot of crushing for other mines in the neighbourhood. The owner told me he had crushed over 30,000 tons altogether, and estimated that he had fully 10,000 tons of slimes on hand awaiting treatment, containing on an average about £1 worth of gold per ton. I am quite unable to reconcile these figures with the official returns, which show only 8,790 tons crushed from the Never Never lease up to the end of June, 1908, for a yield of 2,326.30ozs. of fine gold, equal to an average of 5.3dwts. of fine gold per ton. The official returns from the other mines known to have had their stone crushed at the Never Never battery do not make up the total to even half the figure given to me by the owner. The working costs of mining and milling were stated to be about 12s. per ton.

The Never Never mine has been worked as a low-grade concern, and seems to have every prospect of being carried on successfully as such for some considerable time to come, while the ore is easily obtained in the oxidised zone. It is to be expected, however, that below the water level the oxide of iron, now so plentiful in the ore, will change to pyrites, and that the ore will become both harder to mine and more difficult to treat. It is, therefore, highly advisable that development work should be pushed on with all possible speed. to determine the depth to which the easily obtained oxidised ore extends, and what amount of it of payable value is available, also to form some idea as soon as possible of what changes are to be faced in the sulphide zone. The future of the mine as a permanent concern will, of course, depend on the nature and value of the deeper ore, even though there may prove to be a few years' profitable work above water level on oxidised stuff.

Golden Cube, G.M.L. 707.—This lease lies a little over a mile south-west from the Never Never mine, and contains a reef running N. 80deg. E., with dip to southward about 48deg., which has been worked to a depth of about 70 feet from several shafts for a length of over 300 feet. Its course is across that of most of the reefs and lode-formations which have been above described, and it appears to be a distinct fissure reef of quartz, with smooth, distinct walls, penetrating diorite country. The width of the stone varies very much, averaging perhaps 4 feet. In one place it was 14 feet, in others it is very small, the quartz being in lenses, often detached from each other. There is also often a considerable amount of mullocky lodestuff between the walls along with the quartz.

In the shaft at the east end of the workings there is a large dyke of pegmatite, of unknown width, cutting through both country and reef. Being a hard rock this has been a great obstacle to sinking deeper, especially as at surface the pegmatite dyke appears to be a wide one, and the depth of it to be sunk through may, therefore, be considerable. From the behaviour of the other pegmatite dykes of the Yilgarn Goldfield, however, it is pretty certain that the dyke will not affect the reef except in so far as it causes a large blank in its continuity and constitutes an obstacle to progress, and that the stone will be found to continue on the other side of it. Two other smaller pegmatite dykes have been found in other parts of the mine.

The recorded output of the Golden Cube lease to 30th June, 1908, is 421.14ozs. of fine gold from 1,126 tons crushed. This does not agree with the figures given to me by the owners, who told me that about 1,400 tons had been crushed for returns averaging nearly an ounce of gold to the ton. The tailings sands were said to assay 3 to 4dwts. per ton.

The Golden Cube appears to me to be a mine worth opening up at deeper levels, the reef being of workable size and gold-bearing for a fair length.

Great Victoria, G.M.L. 719.—This mine is situated a little over 1½ miles south of the Golden Cube, and from its position seems likely to be on a continuation to the south-east of the belt of large lode "formations" seen at the Marvel Loch and Jacoletti. The strike of the outcrop of the huge lode which has been opened up on the Great Victoria is about N.W. and S.E. which agrees very well with this supposition. The outcrop is a wide mass of brown iron ore and quartz, the latter often laminated, considerably over 100 feet in width. It has been tested by surface cuts and crosscutting from three shafts 50 to 60 feet deep. In one of these the crosscut goes 107 feet into the lode and in another over 90 feet without finding the walls. The lode matter is broken up laminated quartz and dark jasper with cellular sintery quartz and much brown oxide of iron, often pulverulent. A little gold is found right through the mass, the ore varying

very much in value. Assays up to 3 ozs. per ton are said to be obtainable occasionally, but the average ones appear to be from 3 to 7 dwts. of gold per ton, according to samplings which have been shown to me. The ore body has been repeatedly sampled, and while there seems to be great unanimity among those who have tested it as to its being almost always more or less gold-bearing, it appears to have been generally regarded as averaging rather too low a grade to be successfully worked. I cannot express an opinion on this point from personal observation, having had no opportunity of devoting the time to the mine requisite for sampling it. The returns from actual crushing tests which have been recorded to 30th June, 1908, are 220.83ozs. of fine gold from 1,056 tons of material or nearly 4.4 dwts. of fine gold per ton actually recovered. This would not include gold in the tailings, some of which could be recovered by cyanide treatment, and if it fairly represents the mass of the lode the latter should in the circumstances be a payable workable proposition. The tonnage crushed must have been almost all that has been broken, as there is little loose ore to be seen on the mine, and with this in mind it seems to me that there is very great hope of the mine being a success. The lode is of such huge size, however, that a great deal of work is required in driving through it sufficiently to test it even to say 50 feet depth. The prospects thoroughly warrant the expenditure necessary to prove the extent and value of this great ore body, but until more underground work has been done it is yet premature to be very confident that the average bulk value will be payable. If it can be treated in bulk without much selection it will be possible to break out the ore very cheaply in open-cut workings, as has been so successfully done at the Never-Never mine. The Great Victoria, however, has a much wider ore body than that at the latter mine.

The ore body appears to be quite similar in its origin to that of the Never-Never mine above described. As it is more ferruginous it is probable that it will contain even more sulphides in depth. The mine is on fairly high country, and it seems likely that the water level will not be less than 200 feet below the surface, and very possibly the 300 feet level will be reached before sulphides become troublesome. There must be an immense amount of ore in the oxidised zone without reference to the sulphides. As at the Never-Never, however, it would here be strongly advisable to find out as soon as possible what changes are to be expected in depth by sinking a shaft down into the sulphide zone. There might very possibly, even probably, be an enrichment of the upper part of the sulphide zone as suggested in the case of the Transvaal mine at Southern Cross previously described. In the oxidised ore some of the gold is plainly of secondary origin, being seen to occur in thin coatings on joints of pieces of brown iron ore, which is itself a secondary mineral, resulting from oxidation. There is therefore much possibility of the oxidised part of the lode having been impoverished near surface, and of its gold having been reprecipitated lower down on the sulphides.

The Great Victoria is one of the most interesting ventures at present in the Yilgarn Goldfield as it offers great promise of becoming a very large mine if developments continue to result as favourably as hitherto, though probably always likely to be a low-grade concern.

A water supply will become an urgent necessity very soon to enable the ore to be milled on the mine. It will probably be necessary to go some considerable distance away into the low country to get a well which will yield a battery supply of water, and in the immediate vicinity there does not seem to be any more likely place to get water than in the lode itself. It is part of a large fractured belt of country, likely to contain much water in depth, and I would therefore urge that a shaft be sunk in it below the water level, say to 300 feet, before trying elsewhere. This shaft is required for prospecting the lode even if water were not found in it.

Allendale.—This is a new find lately made about three-quarters of a mile W.S.W. from the Great Victoria. There is a large outcrop of brown iron ore and quartz running about N. 20 degrees E. and apparently underlaying westerly. The outcrop is traceable for a long distance, and is frequently composed of ferruginous laminated quartzite, which in parts appear to have been disrupted, with subsequent formation of quartz and oxide of iron in the fracture. Very little work had been done on this lode when I saw it, there being only a little surface trenching, but some gold had been obtained in good-looking quartz. The prospector informed me that he could get gold by dollying the quartz "floaters" for a long distance along the outcrop. The lode is evidently a large one, the outcrop being often 50 feet wide, and seems well worth prospecting.

PARKER'S RANGE CENTRE.

About 5 miles S.S.E. from the Great Victoria we come upon the north end of the Parker's Range auriferous belt, comprising a number of reefs and veins with a general N.N. Easterly strike. The most prominent are of the laminated ferruginous quartzite type, and are easily traceable long distances on surface by their large prominent outcrops. It is noticeable that this belt is striking quite across the general course of those of the Southern Cross and Jacoletti centres. At the Blue Hill mine, 3½ miles farther east, however, which is nearly on the line of the Jacoletti group of lodes, the reefs run N.W. and S.E. and may therefore be on the southern continuation of the same main line of fracture.

Blue Hill, G.M.L. 520.—In this lease there are two parallel quartz reefs about 70 feet apart striking N.W. and S.E. and dipping 45 degrees to the N.E. which have been worked upon at surface for a length of about 600 feet. The principal workings are from a shaft 170 feet deep on the underlay sunk on the eastern reef. At the

bottom level the reef has been driven along for 200 feet to the N.W. and 300 feet to the S.E., but the shoot of best ore was only about 80 feet in length and averaged about 2 feet in thickness. In the workings the lode is seen to consist of about 18 inches of quartz with up to 6 feet in thickness of shaly diorite schist mixed with quartz veins. I saw some excellent specimens of coarse gold in mere films of quartz between laminæ of the shaly blue diorite, and some of this material has therefore to be treated as ore. The apparent wall rock has therefore to be constantly tested for gold, as good values are liable to be passed over unless this is done. A good deal of the shaly diorite has been broken out in stoping, showing a succession of smooth "walls" one behind another. The lode appears therefore to have been in the first instance a "shear-zone" in the diorite, in which quartz veins became formed through the subsequent opening of fissures along it.

The western reef has been poorer in gold than the eastern one, and is only worked down to about 75 feet. One hundred and sixty tons are said to have been crushed for 54 oz. of gold. The mine was not being worked at the time of my visit. It has a 5-head stamp battery. The recorded returns to 30th June, 1908, are 1,627.94 oz. of fine gold from 1,071 tons of stone crushed.

Golden Rod, G.M.L. 761.—During 1907 this lease, which lies S.E. from the Blue Hill, crushed 137 tons of stone for a return of 62.10 oz. of fine gold. It was not working when I was in the district and I did not visit it.

Australia, G.M.L. 508.—This lease is on a strong outcrop, or series of parallel outcrops of laminated quartzitic lodestuff forming a wide mineralised zone striking a little east of north in which three or four veins in the main "formation" have been worked for gold with some success. The most easterly vein is known as the "Eastern lode" and 200 tons of ore from it are said to have given a battery return of 6 dwt. per ton by amalgamation alone. The reef is about 4 feet wide, and is composed of much ironstained amber-coloured quartz, sintery quartz, and brown oxide of iron, lying conformably with the foliation of the main jasperoid "formation." From the north end of this reef a crushing is said to have returned 4 dwt. of gold per ton in the battery. Some 70 or 80 feet farther west is the "Just-in-time" reef, best seen towards the south end of the lease, but which has been opened up right through its length, in about five places. According to the owner of the lease, this reef for 150 feet in length and a depth of 60 feet, returned an average of 25 dwt. per ton, the vein being 5 or 6 inches wide, and from 60 feet to 110 feet it gave 2½ oz. to the ton. Farther north it is a little larger, being about 18 inches thick, and for a length of 50 feet and depth of 90 feet gave an average of 16 dwt. per ton in the battery. This vein is fairly pure quartz, of good-looking appearance. About 40 feet farther west in the south part of the lease is Thorn's reef, which

has been worked for 300 or 400 feet in length along the outcrop down to about 40 feet in depth. The crushings are stated to have averaged 12 dwt. per ton over the battery plates.

The principal gold-bearing vein of this mine, however, has been a somewhat curious "cross reef" which runs in zig-zag fashion across the main "formation" on a N.W. and S.E. general course for a length of about 300 feet. It is not clear if it goes into the country outside the large "formation," or if it is merely a cross-fracture in the latter. From its very serpentine course it does not seem likely to have been a fault fissure. This reef has yielded a large amount of what is stated to have been very good quartz, but as most of this was taken out in the early days of the field there does not appear to be any available record of its actual production. The old workers went down nearly to 100 feet but water then became troublesome, the mine being close to a salt lake. The workings show the reef to have been up to 10 feet wide, averaging perhaps 5 feet. The present owner has crushed 300 to 400 tons, containing a good deal of mullock, for an average return of about 12 dwt. per ton in the battery. He has sunk a shaft 110 feet and was preparing to sink to 150 feet, but had been stopped by the water, which makes at about 300 gallons an hour. An oil engine and well pump have now been obtained to enable sinking to be resumed. The mine has a small 5-head battery but no cyanide plant, and there are said to be 1,200 tons of tailings awaiting treatment. The officially recorded returns from this mine to 30th June, 1908, are 1,353.72 oz. of fine gold from 1,968 tons of ore crushed. Of this 20 tons crushed this year have yielded 77.57 oz. of fine gold.

The owner of the mine, Mr. McKenna, has had a very hard struggle to work it single-handed, having to reopen it below the old workings and under water-level with very small means. He seemed very confident that he could however soon get over his worst difficulties if his pumping plant did what was expected of it. According to its record the mine seems a very promising venture, not only on account of the richer ore of the cross reef, but also, if a larger mill were provided, as a low-grade concern, there being apparently a large amount of low-grade ore in the big "formation." It appeared to me to be one that very well deserved attention from mining investors on the lookout for promising mines in which to acquire interests in return for machinery and development work.

The richness of the cross-vein as compared with those running with the "formation," is quite in accordance with the experience of some of the mines at Boogardie in the Mt. Magnet district where cross-veins have been found traversing the large jasperoid "formations" of similar character to those of this district.

Rickey's.—Going S.S.W. from the Australia lease we find the ironstone and jasper outcrops continuing strongly, and there are old workings, said to have been of the "Beaconsfield" and "Union"

mines, about which I have obtained no information. Where the outcrop runs into an arm of the lake near the old Parker's Range townsite it is very prominent, and has been worked in "Rickey's" old mine. The strike of the laminated jasperoid lodestuff is here N. 15 degrees to 20 degrees E., and dip 40 degrees north-westerly, and some work appears to have been done on quartz veins in the main mass running with it. The principal vein however was a cross-vein coming in on the eastern side, but of which very little can now be seen. The similarity of this occurrence to that of the richer auriferous cross veins in the Australia and McIntosh mines at once suggests itself.

Golden Gate.—The same or a parallel line of lode continues south from Rickey's and has been worked close to the Parker's Range township in some old shafts a short distance N.E. from the Terminus Hotel. The ground being low-lying and close to the edge of the lake the old shafts mostly have water in them, and very little can now be seen. The course of the lode at surface is N. 10 degrees E., and the stone appears to have been about 3 feet in width in weathered diorite schist country with much kaolin. A small pegmatite dyke is seen to the north of the principal workings, and close to this a very rich leader is said to have been worked, and there was a good deal of alluvial gold got on the surface. I was informed by Mr. André that he had crushed 30 tons of ore from the old dumps on this mine for a return of 6½ dwt. of gold per ton over the battery plates, with tailings assaying 3 dwt. per ton.

Some 6 or 7 chains west of the Golden Gate lode there is an outcrop of quartz and ironstone almost under the site of an old hotel on the Residence Areas which is said to carry a little gold. It seems worth prospecting.

About 200 yards south-east from the Terminus Hotel there is an old shaft sunk about 15 feet in alluvial material, the stuff on the bottom being somewhat rounded quartz gravel and ironstone, forming ferruginous cemented "wash" of rather promising appearance. The gravel is covered with loam and concretionary ironstone. This indicates a possible lead of alluvial matter running eastward into the lake to the south of the Residence Areas, which might be worth prospecting. Similar leads running into the flats surrounding salt lakes, and often pretty deep below the surface of the ground, have been worked at Princess Royal and Lady Mary, near Norseman, near Bulong, Kanowna, Paddington, and elsewhere, and any alluvial lead of this type going into probable deep ground, seems worth attention from prospectors.

Ell-Ess-Dee, G.M.L. 751.—This lease lies to the north-west of the Parker's Range Government Tank a short distance, and contains two or more reefs running N. 10deg. to 20deg. E., and underlying west about 1 in 3, on which a good deal of prospecting work has been done. The main shaft is sunk 100 feet, and met with a good

deal of water, said to be about 400 gallons per hour. There is a fairly wide belt of probably sericitic schist, coloured green at times with fuchsite, and full of ramifying small veins of quartz, with occasional larger bodies running parallel with the main lode, which is probably properly to be considered as a lode of the "shear-zone" type. The wall rock appears to be much harder diorite. Most of the mining has been in pursuit of the quartz veins, some of which are rich, but there appears also to be gold in the clayey lode-matter. Twenty tons of this "mullock" are stated to have returned 3½dwts of gold per ton over battery plates, with tailings assaying 4dwts. per ton. The principal quartz vein worked was about 2½ feet wide, and is said to have returned about an ounce of gold per ton. The officially recorded output from this lease to 30th June, 1908, is only 28.61ozs. of fine gold from 26 tons crushed, but probably the older returns were not recorded, or are added in among those from "Voided Leases." The mine was known as "Merrall's" in the early days of the field. It was not being worked at the time of my visit.

Queen of Sheba.—This old mine lay a short distance north of Merrall's on probably the same line of lode. Some gold is said to have been obtained, and there were considerable alluvial workings on the surface.

Piemonte, G.M.L. 769.—To the West of the Ell Ess Dee line of lode, about 30 chains, there are several old leases taken up on a parallel north-north-easterly line of lode, but I have not obtained any information about these. The same line of lode, however, judging from the location of the leases, seems to extend southward, and is very probably that seen in the Piemonte, McIntosh, and Garibaldi (or Triumph) leases.

The party who had been prospecting the Piemonte had, unfortunately, abandoned it just before my visit, being unable any longer to find payable gold. There is a big, strong lode up to 12 feet wide, running through the lease on a course N. 10deg. to 20deg. E., and underlaying about 1 in 4 easterly, on which two shafts have been sunk to 50 and 75 feet. The reef has been stoped for about 100 feet in length, but usually only portion of it has been taken. The lode consists of shingly diorite and quartz veins, the quartz often forming large masses and veins several feet in thickness. There is said to have been some gold in the dioritic lodestuff as well as in the quartz. The lode seems to have been originally a laminated shear zone in the diorite, in which subsequent fracturing has allowed extensive formation of quartz veins, the latter, therefore, occurring bunchily and irregularly between the main walls, and being much mixed with blocks of schistose lode matter. So far as I have been able to learn the bulk of the quartz is very poor in gold, and the values obtained have been in special veins traversing the "formation." To end of June, 1908, 259½ tons are recorded as having been crushed for 44.93ozs. of fine gold, of which 5.96ozs. were dollied from rich

specimens. The reef seemed to me to require very careful sampling from wall to wall, trying dioritic lodestuff as well as the quartz, in order to find if there are any specially good gold-bearing veins, and also to determine if there is any chance of the bulk of the ore being treated successfully as a low-grade proposition.

McIntosh, G.M.L. 750.—This mine was extensively worked in the early days of the goldfield, when it had an equipment of winding machinery and its own battery, all of which have long been removed. The only official record of milling results which I have been able to find is that in 1902 29 tons were crushed for a return of 17.17ozs. of unrefined gold, but this could only have been a trial crushing long after the principal workings were made. Mr. André has informed me that he cyanided about 15,000 tons of tailings sands at the old McIntosh battery, most of which came from the McIntosh mine. The milling returns from the battery are said to have been about 25dwts. per ton, and the tailings sands were found by Mr. André to assay about 4½dwts. of gold per ton and the slimes 6 to 8dwts. per ton. Probably, therefore, fully 20,000 tons of ore were crushed from the mine, an amount not at all difficult to believe when one sees the extent of the old stopes. The mine, however, was deserted soon after the opening of the Coolgardie and Kalgoorlie fields, largely in consequence of attention being then entirely diverted to these more brilliant discoveries.

The mine is a difficult one to describe without the aid of plans, or, better, a model of the workings, the shape of these being very unusual. The vein of quartz which has been principally mined follows a most erratic zig-zag course and dips also very variously when followed downwards, the fissure in which it has formed having been evidently a very irregularly-shaped one. Its anomalous shape, however, becomes more intelligible when it is seen that, like the very similar zig-zag cross reef above described in the Australia mine, it traverses an older lode "formation" of large size, breaking across this from its western to its eastern wall. This main "formation" is a large "shear zone" lode 20 to 50 or more feet wide of diorite schist and laminated diorite much altered by lode-forming agencies together with crushed country and numerous veins of quartz running between N. and N.N. Easterly. The zig-zag quartz reef is on the western side of this "formation" in the southern part of the workings, but when followed to the north it breaks across it irregularly and then is followed for a short distance to the north along the eastern wall. The quartz bodies are largest and of most importance where they cross the main lode "formation," some of the stopes having been taken out as much as 18 feet wide. To complicate matters still more than is due to the irregular shape of the quartz vein both it and the main formation, as well as the enclosing country, are penetrated by two or more pegmatite dykes (so-called "mica bars") which pass through the whole of them indiscriminately. The con-

torted shape of the quartz vein might be taken to be due to these dykes, but I do not think it is so, as the latter are here, as everywhere else I have seen them in the Yilgarn field, clearly of much later date of formation than the quartz reefs, and cut clean through them, without apparently faulting them to any extent or exerting any specially favourable or unfavourable influence on their gold values.

The old main working shaft is said to be down to the 137ft. level, but at the time of my visit everything below the 90ft. level was under water. The shaft is vertical for 30ft., then goes on the underlay of the quartz reef, which is about 1 in 1 to the west. A party of prospectors who have lately taken up the mine again were getting some very fair auriferous quartz at the 90ft. level below the old workings. The quartz contained a little pyrites with occasional specks of copper-pyrites and appears to be going down strongly. A little schelite has also been obtained.

A main vertical shaft has been begun by the former owners south of the workings on the cross reef, and is said to be down 117 ft. and to have a crosscut at 100 feet. Below 60 feet it is in very hard laminated diorite, often carrying quartz veins and pyrites. In the crosscut a large pegmatite dyke is cut containing large pieces of orthoclase felspar, an analysis of which is given in Mr. Gibson's Geological report. Small garnets are often seen in the pegmatite.

According to what I could see in the mine down to the 90ft. level and the information given to me about the deeper workings there is much reason to think that this mine has still a good future before it and is well worth re-opening. The ore shoot is of irregular shape and hard to follow and there does not seem to be any great length of it known to be auriferous outside the portion which crosses the main formation, but once its nature is understood there seems no great difficulty in following and working it. The pegmatite dykes which have been so troublesome appear to be dipping faster than the quartz reef and to have passed into its footwall already, so that the quartz body may now be expected to be free from these. The large one in the crosscut from the main shaft will, however, probably yet be met with in depth after a time. An inclined shaft on the ore shoot will probably be found the best to enable the ore body to be worked downwards expeditiously and economically.

Polson's P.A. 130.—A shaft has lately been sunk to a depth of 60 feet on the line of the McIntosh main "formation" on the adjoining ground to the south. It passes through hard, somewhat laminated diorite with frequent quartz veins, probably a little altered portion of the "shear zone," but at the time of my visit no gold-bearing ore had been met with.

Two-up.—There are some old workings known by this name some little distance east of the McIntosh on what very possibly is the Ell-Ess-Dee line of lode. They extend for about 100ft. along the surface and are said to go down about 50ft. A quartz vein ap-

pears to have been worked, which was probably of small size, but there is a good deal of schistose lodestuff also. Parts of the quartz vein are said to have been very rich.

Spring Hill, G.M.L. 724, and *Spring Hill North*, G.M.L. 760.—These leases are on what seems to be the same large lode of laminated dark jasper, brown hematite, and quartzite as is seen further north in Rickey's and the Australia mines, the outcrop being traceable almost continuously right along. The same, or a very similar and closely parallel line, continues southward to the Dulcie Jean lease, G.M.L. 746, and probably for a long way further. The regular laminated structure shows that it was in the first place a "shear zone," and probably a line of considerable faulting. The laminated outcrop is often 30 to 50 or more feet in width. In the Spring Hill mine we find the same feature as in the Australia, namely auriferous veins of quartz and iron oxide lying in the foliation of the main lode, but apparently due to faulting movements on the old line of weakness subsequent to the formation of the laminated quartzites.

The Spring Hill mine was formerly known as the Carlisle, and was worked a good deal in the earlier days of the Parker's Range field. The main shaft is down 160 feet vertically, at which depth there is a crosscut west about 28 feet which has not yet cut the lode. At 100 feet it cuts the footwall of the "formation" and above that level is sunk in the lode matter. The lode strikes N. 15deg. to 20 deg. E., and dips 40deg. to 45deg. westerly. In the stopes the older workers appear to have confined themselves almost entirely to a vein of bluish granular quartz of kindly appearance, 2 to 4 feet thick, but the present owner is now going through the workings again and taking out the ground 6 to 7 feet wide, between two hard, smooth walls of hard silicious laminated brown iron ore. The vein stuff extracted is a mixture of rubbly quartz, cellular and sintery quartz, oxide of iron, often pulverulent, and kaolin, yielding about 6dwts. of gold per ton by battery treatment. The vein has proved auriferous on surface for fully 7 chains in length. At the 100 feet level the laminated ironstone seen on surface appears to be changing to laminated weathered diorite to a considerable extent. Some of the foliated kaolin portions have been found worth extracting for the gold values in them. The workings are now down nearly to water level, and deeper developments should throw much light on the behaviour of these lodes below water level. A large quantity of sulphides must be expected, much of the shallower ore being plainly only the residuum of oxidised pyritic lode matter. There seems no reason to fear for the continuance of the main quartz vein, and probably the pyritic matter accompanying it will also continue to carry values. The owner proposes to carry down an inclined shaft from the 100 feet level.

There is a good 5-head battery on the mine and some cyanide leaching vats but as yet no provision for slimes treatment. The bat-

tery crushes for the public under agreement between the owner and the Government. Water is rather scarce, but will probably be plentiful enough when the shaft is sunk well below the water level in the big "formation."

To 30th June last these two leases have been recorded as producing 238.81ozs. of fine gold from 901 tons of ore crushed, but this does not include the gold obtained by previous owners. The Carlisle G.M. Cy. are recorded as having got 58.75ozs. (unrefined) of gold from 36 tons crushed previous to 1900 from Lease 216; in 1900 and 1901 the Enterprise Lease (G.M.L. 491) gave 179ozs. (unrefined) from 750 tons crushed, and the Mining Statistics for 1903 also show 110ozs. of unrefined gold obtained from 116 tons crushed from Lease 528 (491), the "Gordon Highlander," these leases being over the same ground as existing G.M.L. 724, but I am not aware if these figures express the whole of the production of gold by earlier owners. From the extent of the old workings I think there must have been a good deal more ore crushed of which there is no official record.

Gordon Highlander, G.M.L. 668.—This lease lies south of the Spring Hill, on the same line of lode, but in it the quartz vein appears to have been smaller. A good deal of work has been done but none of it to any considerable depth. No one was working this mine at the time of my visit. The Mining Statistics to end of June, 1908, show 117 tons crushed from this lease, No. 668, for a return of 44.42ozs. of fine gold, of which 14.37ozs. were got from dollied specimens. As with all the other mines on auriferous veins in the large "shear zone" lodes intelligent attention should in this case always be paid to prospecting the main lode body for values in gold and for parallel veins of quartz as well as following the one known gold-bearing quartz vein.

Garibaldi (formerly Triumph), G.M.L. 736.—This mine was not accessible at the time of my visit, having been abandoned some time previously. It has a quartz reef in it running north-easterly and underlaying to N.W. which may be on the McIntosh line of lode. The country is hard diorite, which became very hard below the water-level. Several shafts have been sunk, some of which have evidently cut a large pegmatite dyke. The last party to work this mine obtained a loan under the Mining Development Act, and got a small steam plant, but the water and hard ground proved too expensive for them and they had to abandon the venture. They crushed 70.50 tons of ore for a return of 38.98ozs. of fine gold. Under the older name of the "Triumph," G.M.L. 532, the mine is credited in the Mining Statistics with 248 tons crushed for 94.55ozs. of unrefined gold in 1903. There is said to be a fairly good little reef in the lowest workings, but it is in very hard ground.

Dulcie Jean, G.M.L. 746.—On this lease there is a large outcrop, 30 to 40 feet wide, of laminated ferruginous quartzite and silicious hematite, with dioritic schist, running about N. 10 degrees

to 15 degrees W. and dipping westerly 45 degrees. The small quartz vein which has been worked is accompanied by 2 or 3 feet of schist and, with it, is interlaminated between hard layers of silicious hematite. It has been worked on the underlay to a depth of about 100 feet, the vein of quartz being very small but fairly rich. To 30th June last 108.75 tons crushed have returned 161.35 ozs. of fine gold.

Cheriton's Reward, G.M.L. 772, also *Battler's Hill,* G.M.L. 771, etc.—About 18 miles S.E. from Parker's Range there is a piece of country lately discovered by Mr. Cheriton, which has attracted much public attention under the name of "Cheriton's Golden Mile." Several leases have been applied for, alongside the prospector's Reward lease, along the southern slope of a low ridge running W.N.W. and E.S.E. and a good deal of prospecting work has been done. Along the south side of the Reward lease hard diorite schist country is seen cropping out, with foliation running N. 40 degrees W. and dip N.E., and north of this outcrops of a pegmatite dyke are seen in several places, containing large pieces of felspar and big scales of mica, and also at times carrying much black tourmaline in large crystals. The ground prospected is a wide belt of weathered diorite, extending for several chains in width, full of veins of quartz running in various directions. The main belt appears to have a general strike about W.N.W. and E.S.E. The work which has been done is not sufficient to enable one to be very positive about the nature of the occurrence, but it seems most likely that we have here again another example of the same sort of deposit as has been above repeatedly described, namely a zone along which the country has become strongly foliated as a result of great shearing stress, and which has afterwards been disrupted and shattered along the same line of weakness, allowing formation of irregular quartz veins throughout the shattered zone.

Several shafts have been sunk, one 70 feet deep, two to 50 feet, one to 25 feet, and one to 18 feet. The 70ft. shaft is about the centre of the Donna Rita lease, No. 770, and is sunk on a vein of iron-stained quartz which underlays about 8 feet to the south in the depth of the shaft. At the bottom there is a crosscut about 15 feet in length through white, laminated, clayey rock dipping southerly about 60 degrees. There are two small quartz veins about 3 feet apart, of poor assay value.

"Mandelstam's" shaft on Battler's Hill lease is down about 50 feet on a nearly vertical reef of quartz up to 4 feet wide, but 10 feet above the bottom of the shaft the quartz disappears. Crosscuts have been driven north and south from the bottom of the shaft in laminated kaolin, dipping south about 45 degrees, without seeing any trace of the reef. The kaolin may be a fault cutting the reef but I am inclined to think that if the quartz is followed it will not be found to be regularly cut off, but simply to have formed in a fissure

which failed to penetrate the kaolin at the point where the shaft went down, but very probably continues downwards elsewhere. The quartz in this case was poor in gold.

On the south side of the zone in lease 771 a vein has been found running about N. 30 degrees E. and dipping north-westward about 60 degrees on which a shaft was being sunk at the time of my visit. The shaft was an iron-stained quartz from 2 to 6 feet wide in which some very fine specimens of coarse gold have been found, but which was very poor in two panning tests tried by me. This vein seems to run across the general W,N.Westerly course.

On the Reward lease, No. 772, about 4 chains from the east boundary there is a shaft down about 18 feet on a reef of quartz 6 feet thick dipping flatly southward. In the bottom of the shaft the quartz gives place to diorite, but probably this is only a "horse." Mr. Cheriton informed me that part of the crushing of 33 tons which he had made at the Spring Hill Battery came from this shaft. This crushing is stated to have returned 3 dwts. of gold per ton over the battery plates, and to have given tailings assaying 18 dwts. and 11 dwts. per ton. There does not appear to be any official record of this crushing, all that has been recorded being one crushing of 6 tons from Battler's Hill (G.M.L. 771) which returned 5.97 ozs. of fine gold. Mr. Cheriton informed me that this stone came from three shallow cuts on outcropping reefs, and that the tailings assayed 3 dwts. 12 grs. of gold per ton.

Numerous veins are found cropping out all across a belt of country 300 to 400 feet wide and small prospects of gold seem to be quite commonly obtainable from these. So far as I could ascertain, however, in a short visit, the most of the stone is poor in gold. There are so many veins to be tried that prospecting them all is a very considerable undertaking, and to find if there is anything worth serious mining upon will require both time and money. Very systematic crosscutting through the zone of veins and constant testing are required to discover if there are any ore-bodies fit for mining on a large scale, and to do this requires a good deal of capital. In the hands of prospectors dependent on getting returns from crushings, all that can be hoped for is that the richer veins will be sought for and sunk upon, and in the course of this work it may become apparent that the proposition can be worked on a larger scale. So far as the development has yet gone there does not appear to be much inducement to put a battery on the ground, but, on the other hand, without crushing facilities close to the mine there is no hope for prospectors to make a living out of the ground. On the present showing, nevertheless, it seems to me that it would be better not to go to the expense of a battery until better supplies of good ore are certainly in sight.

A Government well has been sunk about half a mile to the south, which yields a small supply of salt water. Mr. Cheriton in-

formed me there was enough for a 5-head battery, but so far as I could ascertain the supply has never been tested by pumping. It is said that the contractor was unable to finish sinking the well its full depth on account of the amount of water met with, which seems promising for a supply large enough to keep a small battery going.

My short visit to Cheriton's leases did not allow very close examination of them, but enough was seen upon which to form an opinion that the locality is well worth continued prospecting. There is a large number of quartz veins which have been proved to carry a little gold, and some really good "specimens" have been got, while the "formation" as a whole seems quite similar to other large lodes on the same belt of country extending through to Southern Cross. There did not appear to me however to be any justification for putting a high value on the discovery as at present developed, or for regarding it as more than a purely prospecting proposition.

Mt. Caudan Iron Deposit, M.L. 8, "King's Cairn."—No description of the Parker's Range field would be complete without some reference to the huge iron lode lying two miles W.N.W. from the township, called King's Cairn on the map, but more commonly locally known as Mt. Caudan, after Mr. Armand Caudan, who has been greatly interested in trying to bring it before European capitalists. This is a huge outcrop of brown iron ore rising to a height, estimated without actual measurement, of fully 100 feet above the flat ground to east and west of it. On the east side there is a somewhat precipitous face, but the hill slopes gently towards the west. The outcrop is often 50 feet in width, and probably more, and strikes N. 10 degrees to 15 degrees E. with apparently a westerly dip of about 45 degrees. It is easily traceable for about half a mile in length, and I was informed that it could be followed for about six miles to the south, and a long distance to the north. The lodestuff is a very pure hard brown hematite, usually somewhat dense and massive but occasionally cellular and stalactitic, which often shows a distinctly laminated structure parallel to the strike of the deposit. Only one small cut has been put into it to test it below the surface, and in this there are some small veins of quartz ramifying through the mass. The eastern or footwall side of the lode appears to be somewhat more silicious than the western portion, but the great bulk is very free from silica.

There is no doubt in my mind about this deposit being a lode of the laminated hematitic quartzite series, but at this point almost entirely made up of iron ore. The brown iron ore being a secondary mineral it is very probable that it has been formed by oxidation of a large pyrites body, and if this originally contained any copper there would be a great probability of there being rich secondary ores of copper near the water-level. Nearly all the quartz reefs of the Yilgarn auriferous belt contain a little copper, so there seems some reason to expect that there may be some copper in any large pyritic

ore bodies that exist in the same zone. To the west of this iron lode the country appears to be granite, the lode being close to the contact between the granite country with the greenstones. The vicinity of the contact of these two rocks is a favourite situation for copper deposits in several localities in this State in which this metal has been found.

In Mr. Gibson's report (Geological Survey Bulletin, No. 17) the following partial analysis is given of a sample (G.S. No. 5640) from the top of the hill:—

Metallic Iron	60.38 per cent.
Silica	2.93 „
Sulphur	.068 „
Phosphorus	.038 „
Hygroscopic moisture	.440 „
Combined water	9.12 „

Another sample taken by myself by knocking off a bagful of chips from a large number of separate outcropping rocks has also been analysed in the Geological Survey Laboratory, with a very similar result, viz.:—

No. 1109.

Metallic iron	59.48 per cent.
Silica	3.52 „
Manganese	.17 „
Chromium	.004 „
Sulphur	.086 „
Phosphorus	.054 „
Titanium	Trace.
Copper	Very minute trace.
Vanadium, Tungsten, Molybdenum	No trace.

In this instance search was made for some of the rarer elements which might perhaps be present, on account of information having been given to me on the ground that there was supposed to be a rare metal in the ore which gave it a special value. Chromium was probably the element referred to, but it is present in far too small quantity to be of consequence. The ore is a very excellent iron ore and will doubtless in time to come be worth smelting for the metal, but under existing conditions is valueless. Should copper ores be found in the district the iron ore would be a magnificent flux in smelting them.

It would be a good prospecting venture, in my judgment, to sink a shaft on the west side of the hill to cut this big lode at about the water-level, or to put down some diamond drill bores to prove it.

KOOLYANOBBING RANGE.

The reported discovery of gold near Koolyanobbing Range about 22 miles north of Southern Cross caused a good deal of excitement

during the early part of the present year, but after a number of parties had visited the locality for a short time it was practically abandoned by all but the prospectors, Messrs. Wilson and Kemplay. Their discovery is four to five miles north of the Koolyanobbing range and about the same distance from the older discovery known as Chadwick's Reward, which is almost on the line of the Range. The road from Southern Cross is a very winding one, having been made by sandalwood getters in the course of their work, and is fully 36 miles in length to Wilson and Kemplay's find, though probably not 30 miles in a direct line from Southern Cross. It runs over granite country all the way from Southern Cross to the Koolyanobbing Range, much of which is low-lying flats surrounding Lakes Seabrook and Eva. The granite continues to the foot of the Koolyanobbing Range, which is a prominent range running N.W. to W.N.W. across the country. It is a great outcrop of a large example of the laminated quartzitic lode type, and where crossed by me at two points some miles apart appeared to be well worthy of prospecting for minerals. It is a fairly wide belt of diorite schist and laminated hematitic quartzites, striking N. 35 degrees to 40 degrees W., and dipping north-easterly. At the western road crossing granite country is found again on the north side of the range, and continues east nearly to Wilson and Kemplay's find, but the eastern road through the "Gap" by way of Chadwick's Reward, continues on diorite country from the south side of the Range to Wilson's.

Wilson and Kemplay's Find.—Only a little work had been done on the reefs at the time of my visit and in consequence they were not very well exposed to view. Two reefs were being worked, running N. and S. and N.N.W. and S.S.E., in two shafts about 12 chains apart. The reefs appear to run on lines about 400 feet apart. The south shaft was about 13 feet deep, and showed a strong reef of quartz carrying a good deal of enclosed pyrites, underlaying easterly about 1 in 2. The reef was up to 4 feet in thickness and seemed very promising. I saw gold in some of the quartz and obtained very fair prospects by crushing and panning. The north shaft was down only about 8 feet, on stone about 12 inches wide. The prospectors showed me numbers of stones from this place carrying gold, and I obtained some very fair prospects by crushing and panning samples of quartz showing no visible gold. The prospectors were preparing to get out a crushing of 20 tons to be taken to Southern Cross, and have since been promised assistance from the Government in carting it there. They seemed to have two fairly promising little reefs which would be well worth working if there were crushing facilities in the district, but which would be no use to prospectors if the stone had to be carted a long distance. Their trial crushing will give a good idea of what may be expected from these reefs.

South of Wilson's ground another strong quartz reef has been found, running about N. and S., but only a small cut had been put

into it. I got a fair prospect of gold by crushing and panning off a sample of this. There seem to be several more veins about the locality judging by "floaters" which are picked up. The country is diorite with a good many intrusions of granite and quartz porphyry, being close to the contact of the greenstone country with the granite. There is a little diorite schist, but I did not notice much of it.

As usual with new prospecting districts in this State there is difficulty in getting supplies of fresh water. The prospectors obtain it from a clay-pan about five miles to the north, where they say a dam could be readily made. Near the reefs the surface is too loamy and permeable to afford good catchment for water, but in heavy rains there are some watercourses in which water runs freely, and where it might be caught in dams. Salt water for crushing could probably be got by sinking in some of the lower ground.

Chadwick's Reward, G.M.L. 641.—This ground was applied for in September, 1904, and a good deal of prospecting work has been done on it. One vertical shaft was sunk 101 feet deep with the help of a loan of £100 under the Mining Development Act, and a shallower one had been previously put down on the underlay. The reef is small, being only 8 inches to 2 feet in width, and consists of quartz with a little enclosed pyrites, and seems to be a well-defined little vein. Course N.N.W. and S.S.E., with slight underlay to N.E. It is in weathered diorite country, which in this vicinity seems usually schistose in structure. Only one small crushing of 6 tons has been made, which returned 2.65 oz. of fine gold.

Chadwick's Copper Mine.—The contact of the greenstone country with the granite not very far south of Chadwick's Reward is marked on the road by a large outcrop of white quartz, and other outcrops are seen along the Range on about the line of contact. The diorite country is strongly foliated parallel to the plane of contact and so also is the granite, the latter changing almost to a schist. The foliation does not extend far into the granite however, not more than 200 to 300 yards, and it soon becomes the ordinary massive variety.

About half a mile S.E. of the point where the road crosses the contact a good deal of prospecting work has been done on the quartz reef, which at this place is much smaller, being only 2 to 4 feet wide. Its strike is N. 35 degrees to 40 degrees W., and underlay about 1 in 2 to the N.E. A shaft has been sunk some 30 or 40 feet on it, obtaining quartz much stained with green and blue carbonates of copper and a small quantity of fairly good copper ore in the form of green carbonate and "tile ore" mostly. The copper is not however plentiful enough to be payably workable. The walls of the reef are dark bluish-black schist, much squeezed and often contorted, which seems to be an extreme phase of alteration of the diorite country by pressure. A sample of the better-class ore that had been

picked out was assayed in the Geological Survey Laboratory, yielding:—

No. 1110 C.—Gold, nil.
Silver, 8oz. 7dwt. 17grs. per ton.
Copper, 6.01 per cent.

This return is quite unpayable at present but points to the advisability of further prospecting this reef. It appears to crop out again to the S.E. as a large "blow" of quartz, but I did not visit this. The line of contact between the diorite country and the granite is worth attention from prospectors right along the range.

GOLDEN VALLEY AND MT. JACKSON CENTRES.

As I could not hear of any work being in progress at either of these localities they were not visited. Several reefs are known to exist at Golden Valley, in which gold has been obtained, and at Mt. Jackson one mine has been worked on an extensive scale, having treated 29,097 tons of ore for 19,314.08ozs. of fine gold and 2,305.28 ozs. of fine silver. It is reported that this mine is to have another trial by a co-operative working party.

GOLD PRODUCTION OF THE FIELD.

The attached table, prepared by the Statist of the Mines Department, shows the production of the Yilgarn Goldfield to 30th June, 1908, so far as it has been recorded officially. There is reason to think, however, that many of the earliest crushings have never been recorded, and also that even in later times there have been instances of considerable slackness on the part of mine owners in carrying out their statutory obligation to report the results of all crushings. The grand total recorded production of the field to end of June, 1908, is:—

From alluvial—70.57 fine ozs. of gold.
From dollied specimens—897.28 fine ozs. of gold.
From ore treated—296,762.56 fine ozs. from 700,097.43 tons.
Total—297,730.41 fine ozs.,
with 3,180.16ozs. of fine silver in addition.

MINING FACILITIES.

The Yilgarn field compares favourably in many respects with most others in the State in respect of working conditions, and wonderfully cheap work has been done in consequence profitably in some of the mines, as for instance the Hope's Hill, Haddon, Transvaal, Greenmount, and Never-Never. In these cases the lodes have been large and the ore easily mined and crushed. Labour rates are somewhat lower than in most of the other fields, and stores of all sorts a

little cheaper. The splendid supplies of firewood and mining timber have also been of great assistance. On the other hand, the deeper mines have nearly all a good deal of water to contend with, and most of the smaller mines have had much trouble from erratic distribution of the values. The occurrence of the best ore in veins traversing large broken "formations" also necessitates much cross-cutting, driving, and "dead work" in general, which would not be required with more normal fissure veins. The refractory nature of the ore below water level at the Transvaal and Greenmount mines is likewise a drawback in their cases.

The mining centres near Southern Cross are well situated as regards mining and domestic goods and stores, being close to the railway line, and as the roads are fairly good none of the present outlying Yilgarn centres have much to complain of in respect of cost of carting machinery and stores. Near Southern Cross also the proximity of the Goldfields Water Supply pipe line is a great boon, the town being reticulated with fresh water from it and branch lines having been carried out to all the principal mines.

WATER SUPPLY.

In the districts outside of Southern Cross, however, water supply is a great difficulty, and the progress of the field depends very greatly on its being satisfactorily overcome. Leaving the centres lying north of Southern Cross out of account for the present, as not just now warranting any considerable expense in provision of water supply, it will be useful to discuss the position in this respect of the very promising and progressive groups of mines to the south, at Jacoletti, Never-Never, and Parker's Range. At the first two of these localities there is a very poor supply of fresh water and not a very good one of salt water. The Jacoletti well often has difficulty in supplying the demands upon it for battery water, and so also with the Never-Never battery supply. The water level in many of the mines in these districts is probably about 200 feet below the surface, and it seems necessary to go about 300 feet in order to get any considerable quantity of water in them. Since writing the foregoing part of this report it is reported in the newspapers that the Marvel Loch mine has struck a good supply of salt water in the main shaft at the 300ft. level. If this proves correct it is probable that there will be water also at about the same horizon right along the belt of shattered lode "formations" from the Christmas Gift to the Great Victoria. As the district has an average annual rainfall of over 8 inches there can be little doubt that underground water exists in considerable quantities, and is to be found by sufficient search.

At Parker's Range there are more plentiful supplies of salt water obtainable from the lake and its vicinity, and water for milling purposes can therefore be got pretty easily. At all these places, however, there is a great trouble in maintaining fresh water supplies,

and as the mines become more important this difficulty will increase. At present the most active centre is that which includes the group of mines near the Jacoletti and Never-Never leases, and a supply of fresh water for domestic and boiler purposes for these is very urgently required. The existing supplies near at hand are a small shallow dam near the Golden Cube mine, and a Government rock tank to the N.E. of the Jacoletti mine which holds 50,000 gallons of water when full. Both of these soon give out even with present demands, and water has to be carted from the Cockatoo Rocks and other distant rock-holes, and even, during the end of last summer, all the way from Southern Cross. The rock-tank is an excellent and pure domestic supply, with a catchment of bare granite rocks, but it not nearly large enough for all the wants of the district.

The Engineer of the Mines Water Supply has proposed two excavated tanks, lined and roofed, one to be near the Marvel Loch and another near the Never-Never, the former having a catchment of 400 acres and the latter 910 acres. Estimates have been made, viz.:

Marvel Loch—¾-million gallon tank, £3,500; or ½-million gallon tank, £3,000.

Never-Never—1-million gallon tank, £4,200; or ½-million gallon tank, £3,000.

An alternative scheme has been proposed in May last by the Goldfields Water Supply Administration for a pipe-line to the Marvel Loch from near Bronti Station on the Mundaring to Kalgoorlie main, as follows:—

Proposal A.—4in. and 3in. pipes, 25,000 gallons daily, £6,900.
Proposal B.—6in. and 5in. pipes, 78,000 gallons daily, £14,300.
Proposal C.—8in. and 6in. pipes, 171,000 gallons daily, £22,000.

These costs have, however, now to be revised in consequence of the recent change in the Customs tariff on pipes, and are only quoted to give some general notion of the approximate expenses. It is possible also that changes may be made in the route of the pipe line, to make it serve the belt of auriferous country more conveniently.

In comparing these two schemes it will be seen that the two larger tanks at Marvel Loch and Never-Never would between them hold 1¾ million gallons, and would cost £7,700. The supply might be sufficient for present purposes, if the field were never going to be any further advanced than it is now, but would even now be very doubtful of lasting through a long dry season such as has often been experienced in the district. With four 10-head batteries running constantly it would be no more than sufficient to guarantee boiler water supplies for three to five months. The cost of the water at the tanks would be fairly low, but it would have to be carted to the mines, or else the further cost of pipe lines to them and of pumping stations at each tank must be added.

The Goldfields Water Supply Administration's proposal "A," provides a larger supply of reliable nature, unaffected by droughts,

as far as Marvel Loch for a less cost than the tank scheme. They have not yet, however, given estimates of the cost of a continuation to Never-Never and the Great Victoria. The pipe line would have another advantage, besides that of reliability of supply, in that it could be brought on to the auriferous belt of country and carried along its course, passing within a short distance of most of the mines to be served and enabling them to have pipe connections at small cost. To do this to greatest advantage would probably require a modification of the route of the line on which the above estimates are based.

Proposal "A" would be just about sufficient to meet the immediate domestic, boiler, and milling requirements of the district, and, if salt water were got for milling, might suffice for some years for domestic and boiler water alone even with considerable development of the mines in accordance with their present promise. Proposal "B" would probably be ample for all purposes for several years to come. An extension of it with 3in. pipes to the Great Victoria would be required, increasing the above estimated cost. If put in at once, it would enable batteries up to a total of about 50 stamps to start with fresh water for crushing purposes, pending the mines getting their shafts down deep enough to obtain their own supplies of salt water. By the time that enough salt water could thus be got for all milling purposes, in all probability a large part of the fresh water would be required for power and domestic use.

Taking into consideration the probability of cheap salt water milling supplies being obtainable from the mines' own shafts, it seems to me that proposal "B" will probably be more than ample for all requirements for some years, and that a modified scheme capable of delivering 50,000 gallons a day at Marvel Loch and carrying portion of it on to the Never-Never and Great Victoria mines would be good enough to begin with. Until final surveys of the route have been made and all details of size of pipes, pumping stations, storage tanks, and so on have been settled, it will be best not to attempt any estimate of cost beyond such as is roughly deducible from the approximate figures above given.

Extension to Parker's Range would require consideration if the mines there should open up so as to warrant it. For a time domestic supplies for this centre, when local sources failed, could be carted from the end of the pipe line.

SUMMARY.

The Southern Cross auriferous belt extends for over 50 miles in length, and is usually over five miles wide. It is very full of lodes, especially of large low-grade "formations," but in these and in the adjacent country there are also many well-marked fissure lodes.

Though a large amount of prospecting has been done there are only quite a few of the mines that have as yet been extensively worked, and most of these have been of decidedly low-grade though often profitable. The majority of the "shows" which have been opened have not been able to attract the assistance of enough capital to enable them to be equipped with proper machinery, and have therefore been worked intermittently and at much disadvantage, usually having had to cart the ore considerable distances to be crushed. The low-grade ore bodies most common in this field require treatment close to the mines, with as little handling as possible, and each mine of any size therefore requires to possess its own battery. The field is advantageously situated as regards cost of labour, mining stores, and domestic supplies, and splendidly provided with the best of mining timber and firewood, but outside of Southern Cross itself is at present rather badly provided with salt water supplies for milling, and very badly with fresh water. Both salt and fresh water are, however, obtainable without excessive cost, and in the foregoing part of this report an extension of the Goldfields Water Supply scheme to the southern part of the field has been recommended as the best way of meeting the water difficulty.

The prospects of this field appear to me to be on the whole very promising. There is no field in the State where there are stronger indications of extensive lode-forming action, the auriferous belt being a really remarkable zone of intense and repeated fracturing and crushing of the earth's crust, affording all the geological conditions usually considered favourable for the formation of ore bodies. Good ore has been found more or less all along the belt, and several of the mines seem likely to become of much importance. There is still great scope for prospecting the untried ground for new reefs, and also in the older mines for search in the large "formations" for other ore bodies than those already worked. The district at present seems to me to offer as good opportunities for intelligent prospecting as are to be found in any of the other fields of Western Australia, but recognition must be made of its somewhat unusual features, especially of the prevalence of "shattered zone" deposits, and a wider conception taken of the nature of the lodes than has been usual in the past when the incidental quartz veins have been regarded as alone worthy of attention.

I have, etc.,

A. MONTGOMERY, M.A., F.G.S.,

State Mining Engineer.

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Appendix I.

TRANSVAAL GOLD MINES.

Report on Treatment Tests of Sulphide Ore.

The tests, particulars of which are given below, were undertaken with the object of ascertaining what proportion of its gold contents the Transvaal ore would yield to cyanide by the ordinary leaching process, and at what cost. It is to be understood therefore that when cyanidation is herein referred to, leaching was the method used to apply the solutions.

Test No. 1.

Fifteen pounds of concentrates, collected from the battery launders were roasted on an iron plate and a five pound sample cyanided.

Assay value before Cy. treatment	..	1oz. 8dwt. 0grs.
Assay value after Cy. treatment	..	0oz. 2dwt. 15grs.
Extraction per long ton	..	1oz. 5dwt. 9grs.
Extraction per cent.	..	90.6

Test No. 2.

About eighty-six pounds of roughly broken ore were kiln-roasted, crushed through a screen of 800 holes per sq. inch, and a five pound sample treated by cyanide.

Results were as follows:—

Assay value before treatment	..	1oz. 7dwt. 0grs.
Assay value after treatment	..	0oz. 18dwt. 10grs.
Extraction per long ton	..	0oz. 8dwt. 14grs.
Extraction per cent.	..	30.2

In this sample there was still a proportion of mineral and the cyanide consumption was very great, accounting for the poor extraction.

Test No. 3.

A further quantity of thirty pounds of the kiln-roasted crushed ore mentioned above had a finishing roast in a small reverberatory

type furnace, and the cyanide test was applied to a five pound sample as before:—

Assay value before treatment	..	1oz. 7dwt. 15grs.
Assay value after treatment	..	0oz. 5dwt. 5grs.
Extraction per long ton	.. ..	1oz. 2dwt. 10grs.
Extraction per cent.	.. ..	81.0

Test No. 4.

A representative sample of the working faces in the Sulphide Zone was dry crushed through a screen of 800 holes per sq. inch, and ninety-five pounds roasted as completely as practicable in a small reverberatory furnace. Sixty-two pounds of the roasted product were cyanided:—

Assay value before roasting	..	0oz. 14dwt. 10grs.
Assay value after roasting	..	0oz. 16dwt. 15grs.
Assay value after cyaniding	..	0oz. 3dwt. 12grs.
Extraction per long ton	.. ..	0oz. 13dwt. 3grs.
Extraction per cent.	.. ..	79.0

Test No. 5.

The above operations were carried out in a similar manner on a second sample of ore, the screen used being one of 1,000 instead of 800 holes per sq. inch.

Before roasting, five per cent. of a sample of carbonaceous matter found mainly on the walls of the lode, were added in order to learn whether this substance would be detrimental to successful treatment. Sixty pounds of the roasted product were cyanided:—

Assay value before treatment	..	1oz. 2dwt. 20grs.
Assay value after treatment	..	0oz. 4dwt. 12grs.
Extraction per long ton	.. ..	0oz. 18dwt. 8grs.
Extraction per cent.	.. ..	80.3

The cost for cyanide, alkali, and water consumed in tests 3, 4, and 5 was estimated not to exceed 3s. per ton.

General Conclusions.

Judging from the behaviour of the ore during the above-mentioned operations and the results attained, I am of opinion that dry crushing followed by roasting in some form of mechanical reverberatory furnace and direct leaching with cyanide solutions, is a process eminently suitable for its treatment. Fine grinding and filter pressing would, of course, enable a higher extraction to be obtained, should funds be available for the necessary plant.

As is generally the case with an ore of this nature, containing, as it does, arsenic and sulphur, a sweet roast can be obtained more quickly and at a lower temperature than would be the case with a purely sulphide one.

Very little slime is formed in crushing, and, as leaching took place very rapidly in the tests herein described, finer screens could be used in practice with a consequently higher extraction.

Another very important point to be noticed is that the gold in the Transvaal ore is in an extremely fine state of division, being probably disseminated throughout the body of its mineral contents, and absent from the quartz which forms its other constituent. This fact is apparent on attempting to pan off some of the finely crushed roasted ore; it will be found that, although containing an ounce or more of gold to the ton, it is very difficult to get more than a "colour" in the dish.

These two characteristics (the finely divided state of the gold, and its absence from the quartz in the ore) render it peculiarly amenable to the direct leaching process, since solution of the gold contents takes place very rapidly and extremely fine grinding is inessential.

(Sgd.) C. NARDIN, B.E.

10th April, 1908.

Note.—The ore used in Test No. 5 should closely approximate in composition to that of the sample sent for treatment to the Government, being in common with the latter, a portion of a general sample taken from the mine.—(Sgd.) C. N.

Appendix II.

TRANSVAAL G.M., SOUTHERN CROSS.

Experiments on Treatment of Ore.

Geological Survey of W.A.,
The Laboratory, Perth,
16th May, 1908.

Acting Government Geologist,—

The average sample of ore from the bottom level of the Transvaal G.M., submitted for experimental treatment, consisted of arsenical pyrites and quartz in about equal proportions with a little chlorite and mica. No graphite was seen in the ore.

It showed on assay—

Gold—16dwts. 17grs. per ton.
Arsenic—26.09 per cent.
Sulphur—11.07 per cent.
Copper—0.010 per cent.

It appeared hopeless on such ore to attempt any method of treatment which did not start by removal of the arsenic and sulphur by roasting.

For roasting the ore was crushed through a 20-mesh sieve, the actual size of the screened particles being as follows:—

Passed 20, refused 40—31.2 per cent.
Passed 40, refused 80—28.6 per cent.
Passed 80—40.2 per cent.

The ore was roasted in lots of about 30ozs. at a time, the temperature being kept low for about three hours, then raised to a full red for about one hour more. The ore roasted very easily and completely, giving off large volumes of white arsenic fumes. There was no appreciable loss of gold in the roasting, the roasted ore weighing 78 per cent. of the raw ore and showing on assay:—

Gold—21dwts. 19grs. per ton.
Arsenic—Trace.
Sulphur—0.25 per cent.
Copper—0.013 per cent. (slightly over ¼lb. per ton).
Soluble acidity, equal to 0.051 per cent. H_2SO_4.
Latent acidity, equal to 0.065 per cent. H_2SO_4.

Before proceeding any further with the treatment the sample was further crushed to pass a 30-mesh sieve, the actual size of the particles being:—

Passed 30, refused 40—13.2.
Passed 40, refused 80—34.0.
Passed 80—52.8.

Cyanidation.—50ozs. of ore taken for this test. A water wash equal to 12cwt. of water per ton of ore was used to remove soluble salts. This was followed by an alkaline wash of dilute caustic soda continued until the escaping water gave an alkaline reaction. Then strong solution (0.335 per cent. KCN) left in contact with ore for 19 hours, finally weak solution for 46 hours. After a water wash a sample was taken for assay. This showed 6dwts. 6grs. of gold or an extraction of only 71.3 per cent. The ore was treated with weak solution for a further 48 hours when the residues assayed 3 dwts. 19grs. of gold per ton, equal to an extraction of 82.6 per cent.

Consumption of chemicals per ton of roasted ore—
Caustic Soda .. .. .. 1.2 lbs.
Potassium cyanide .. .. .. 1.9 lbs.
Omitting the water and alkaline wash—
Potassium cyanide .. .. .. 4.9 lbs.
Time occupied—
Water and alkaline wash .. .. ¾ day.
Cyaniding .. .. .. 4¾ days.
Percolation was somewhat slow.

This experiment showed a good extraction with a small consumption of time and chemicals. Doubtless finer crushing would improve the extraction without materially retarding percolation.

Bromo-cyanidation.—30ozs. of roasted ore taken for this test. A water wash was first used, but this was not followed by an alkaline wash as the use of an alkali is inadmissible in this process. The ore was then treated for 19 hours with solution containing 0.344 per cent. KCN and 0.007 per cent. BrCN, the latter being renewed from time to time. The ore was further leached for four days with 0.115 per cent. KCN to which BrCN equal to 0.007 per cent. was added and occasionally renewed. After being thus leached for the same period of time as in the previous experiment the residues were assayed and found to carry 4dwts. 8grs. of gold per ton, the extraction being 80.1 per cent.

Consumption of chemicals—
Caustic soda .. .. .. None.
Potassium cyanide .. .. .. 6.3 lbs.
Bromine .. .. .. 0.7 lbs.

Chlorination (Hall-Richard Process).—30ozs. of ore were leached for three days with chlorine water ranging in strength from 0.203 to 0.275 per cent. chlorine, the solution being renewed twice.

A sample of the residues was taken at the end of the third day and assayed 7dwts. 19grs. per ton, equal to an extraction of 64.3 per cent. Consumption of chlorine 5.42 lbs. per ton, equal to the following chemicals per ton of ore:—

Salt	8.9 lbs.
Manganese dioxide	6.6 lbs.
Sulphuric acid	14.8 lbs.

The final results are given in the following figures:—

Time occupied	5 days.
Extraction	79.9 per cent.
Consumption of chlorine	8.8 lbs. per ton.

(Sgd.) EDWARD S. SIMPSON, B.E., F.G.S.